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On the nature of European holding groups

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Abstract:

This paper develops a new explanation for the emergence of large European holding groups that typically control many of the largest companies of their country. These holding groups usually consist of (sometimes many) non-holding firms (i.e. industrial companies, banks,...) with layers of holding companies on top. The holding firms in these layers may or may not be publicly quoted and often show a very intricate ownership structure, characterised by inter-group connections, intra-group cascading mixed with parallel placement of holding firms, cross ownership and diverse intra-group links. So far no explanation for these complicated structures has been proposed. This paper offers a rationale for this phenomenon. It shows that if ownership is used as a device to develop certain decision power configurations over non-holding firms, holding groups with the features described above develop. Specifically, drawing on European corporate law, it is shown that multi-holding structures with observed inter-group connections develop as a response to the need for a flexible renegotiation free co-operation mechanism. It is also shown that when this co-operation mechanism is placed under the pressure of capital constraints, complicated intra-group ownership patterns are likely to arise. The paper also investigates the interaction between holding firms and shareholder syndicate contracts (considered to be very important in European corporate governance) and, next to rationalizing observed holding structures, it also formulates some additional testable hypothesis about these groups.

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In Continental Europe corporate ownership is typically concentrated. It is well known that in Italy, Belgium and Sweden a few large holding groups control - or at least have influence in - most of the important companies on the stock exchange (see e.g. Baums, Buxbaum, Hopt (1994), Gerson (1992), Van Overstraeten (1994)). Although the situation is not as extreme in France, holding groups like Suez and Paribas control several of the largest French companies and/or belong to their 'noyaux durs' (= hard core of large and controlling block holders). Important holding groups are present in other Continental European countries too, for example in Spain (e.g. TENEO), Portugal (e.g. RAR - Sociedade di Controle) and Denmark (e.g. Accumulator - Invest A/S). A large holding group often consists of layers of publicly quoted and non quoted holding companies, placed on top of the non-holding firms (i.e. the industrial companies, banks,....). Furthermore the ownership structure of the holding firms within these layers usually is quite intricate (see appendix A for examples). In particular, holding firms frequently own shares (large or small blocks) in holding firms controlled by other groups. Within groups, cascading (= a string of holding firms in which each company controls the next one in the line) combined with parallel placement of holding companies and diverse intra-group links, frequently turn large holding groups into spaghetti-like structures. Finally, adding to the general picture of opaqueness, control over the large publicly quoted non-holding firms is frequently also shared between different groups. Overall, these ownership distributions contrast sharply with the dispersed and direct corporate ownership that is dominant in Anglo-Saxon Countries. This suggests that, contrary to the Anglo-Saxon world, in European firms, ownership is used as a tool to design decision-power structures. Hence an understanding of European governance implies an understanding of how this tool functions.

This paper shows that if holding firms are used as a device to develop certain decision power configurations over non-holding firms, holding groups with the features described above, arise. In particular, it is shown that multi-holding structures with inter-group ownership are created when holding firms are used as a renegotiation-free private enforcement mechanism to organize co-operation among companies (or different parties). The paper also shows conditions under which this enforcement may take the form of different groups sharing ownership in the non-holding firms. Furthermore it is shown that the use of holding firms solely for enforcement purposes, need not generate much intra-group ownership. However it is shown that a renegotiation-free equilibrium under pressure of sufficiently stringent capital constraints, produces inter and intra-group ownership with greatly varying block size, as well as overall intricate intra-group ownership patterns. In addition the paper analyzes the interaction between holding structures and shareholder syndicate contracts (i.e. private agreements among large shareholders; these are generally

considered to play an important role in European corporate governance). Finally the paper also discusses those features in European corporate law that turn holding firms into such excellent vehicles for solving renegotiation problems.

Explanations for the emergence of simple holding groups have been proposed in the past. In particular, by setting up a holding firm, dilution of ownership can be avoided (e.g. keep together the family fortune). In turn, this concentration of financial resources, facilitates maintaining large ownership blocks in non-holding firms. Hence other classical motives for the creation of holding companies are monitoring and diversification (see for example Daems (1978)). Obviously these rationales do not explain the complicated multi-holding group patterns described earlier. The last classical rationale for holding firms is tax avoidance. However it is hard to imagine that the currently observed complicated structures of large holding groups, are a simple response to tax laws. First, in Europe, over the last few decades, holding firms have become increasingly tax neutral. Second, over the same time period, to stop capital flight, governments have been creating special legal forms designed to avoid efficiently corporate and/or some types of personal taxes (e.g. co-ordination centers, distribution centers, mutual funds with special tax advantages). This of course does not imply that holdings would no longer engage in tax management. According to practitioners, some of the holdings in a group still serve tax purposes, while others are vestiges from tax management in earlier periods, when holding firms were less tax neutral. However these firms would usually be 100% subsidiaries of the group, and hence it is questionable that 'tax'-holding companies explain the complicated ownership structures we observe (see also Leleux, Vermaelen and Banerjee (1995) for a discussion of opportunities and limitations of tax savings by French holding firms).

It is useful to compare the European holding groups to the Japanese keiretsu and, perhaps surprisingly, to the United States Congress. Although at first glance, holding group ownership distributions remind of ownership in Japanese companies, the holding group phenomenon is quite different. In Japan holding groups were abolished at the end of World War 2. Since then a myriad of cross ownership between industrial firms with common business interests has materialized (see for example Berglof and Perotti (1994), Miyashita and Russell (1994)). Similarly to Berglof and Perotti (1994)'s rationale for the cross ownership between Japanese industrial companies, this paper views holding firms as self-enforcing mechanisms. However the way this mechanism functions with holding firms is very different. Whereas in Berglof and Perotti the results are driven by the threat of the formation of a majority coalition that ousts non-abiding participants, the holding structures are designed to rule out recoalitioning and opportunities for ousting a party. In

contrast, the logic of the holding system as an enforcement mechanism is strikingly similar to the logic of the organization of Congress in the United States. Weingast and Marshall (1988) analyze the way in which US congressmen structure renegotiation-free agreements in the face of non-contemporaneous benefit flows and the impossibility of current legislators to bind a future legislative session. The renegotiation problem is solved by the creation of committees with a specific jurisdiction and veto power over Congress's agenda within the committee's jurisdiction. Therefore, politicians belonging to other committees, can never revoke benefits belonging to a certain committee's jurisdiction, unless this committee agrees to place these issues on the Congress's voting agenda. More generally, Weingast and Marshall show that a system of well defined veto power over specific issues helps solving problems of non-contemporaneous flows and ex-post renegotiation. Similarly to the US Congress committees, holding firms may be endowed with special super-majority arrangements to give a specific party veto power over well defined issues. By appropriately structuring the ownership pattern within a holding group, this veto power may be organized to deal with renegotiation problems arising in co-operations. It may also solve renegotiation problems that arise when the circle of shareholders is broadened to overcome capital constraints. Simultaneously, the holding group may be structured to allow for reorganizations without the need for consent from all other 'committees' (such a general consent would be necessary in the case of US Congress), while the renegotiation-free enforcement features are kept intact.

The idea of holding firms serving as a blocking device is well known to specialists in corporate law (e.g. Ralet (1988), Schrans and Wymeersch (1991)). However to our knowledge, the possibility to turn holding structures into renegotiation-free enforcement mechanisms has never been systematically analyzed, nor have the implications for the structuring of holding groups been explored. The present paper also differs from the work of Gerson (1992) on South African holding groups as the latter does not address the idea of holding firms serving as an enforcement device, nor the issue of intra and inter-group ownership patterns.

The paper is organized as follows. Section 1 presents and solves the renegotiation problem. The solution of this section considers 3 actors and presumes either no or only limited capital constraints. Section 2 extends the solution to many actors. Section 3 considers two-sided capital constraints and section 4 compares holding firms with alternative solutions to renegotiation issues. Finally section 5 offers some conclusions.

1. HOW DOES THE SYSTEM WITH HOLDING FIRMS FUNCTION?

1.1. Problem definition

Holding structures are a very rich and complex subject. To cope with the complexity and simultaneously keep as much as possible from the richness of the subject, this paper uses an open-ended model of a one period renegotiation problem as a benchmark for the arguments. In this model, at time 0, company X has the opportunity to engage into two independent co-operation opportunities, one with company 1 and one with company 2. In this paper 'independence' implies that the projects are not mutually exclusive and that projects do not influence each other. Initially company X is fully owned by its manager M_X.[1] Similarly companies 1 and 2 are managed by their respective owners M_1 and M_2. The co-operation opportunity requires that between time 0 and time 1, firms 1 and 2 independently provide firm X with some input. For example, by transferring some know how to company X, firms 1 and 2 could use firm X's marketing channels. At time 1, co-operations 1 and 2 generate benefits B_1 and B_2 respectively. These benefits are uncertain at time 0 and, for simplicity, are presumed to take the form of private benefits. Furthermore, at time 1, B_1 and B_2 are fully realized through company X while benefit amounts are not observable to outsiders. Hence unless M_1 (M_2) has acquired some negotiation power at time 1, it will receive nothing. Consequently to convince M_1 (M_2) to step into the co-operation, M_X needs a credible precommitment to share B_1 (B_2).[2] However the realization of B_1 (B_2) is associated with an event E_1 (E_2) that materializes with certainty at time 1 and that is observable to outsiders. However E_1 (E_2) does not contain information about the exact realization of B_1 (B_2). Continuing the example of the use of marketing channels, one could think of E_1 (E_2) as any decision by the board of directors of company X related to the co-operation with firm 1 (2). The minutes of the board meeting could be brought in court as evidence that event E_1 (E_2) has occurred. In fact, if, as will always be the case in the solutions discussed below, M_1 (M_2) is represented on the board, it can make certain that this topic gets on the board's agenda. For simplicity it is also presumed that E_1 and E_2 do not overlap. It will turn out that, next to certain rules of corporate law discussed below, this event will be very helpful in setting up a precommitment device. Next to B_1 and B_2, firm X also produces 'general' private benefits B_X that are entirely pocketed by M_X, at least as long as the latter has general control over company X. It is presumed that $B_X > B_1$ (B_2) (i.e. the benefits of control generated by

[1] In France and Belgium M_X is called 'actionnaire de référence'.

[2] If the co-operation would involve a one shot transaction, M_X could solve the problem by simply paying the present value of the estimated benefits at the time that M_1(M_2)provide the input. However, if the opportunity involves a sustained co-operation effort (e.g. because it may affect the competitive conditions in the product market in which the parties operate as long as the co-operation lasts) or if the benefits are very hard to estimate, this alternative is not a feasible solution and a credible precommitment device is needed.

company X are more important than the benefits of control from some co-operation). After the distribution of all benefits, firms are disbanded.

At time 0, the precommitment device is set up by M_X, M_1 and M_2. It will turn out that holding structures offer the most suitable solution. Normally the particular choice of structure will be the outcome of negotiations. However, as it would only result in one special example or subclass of holding group, this paper does not identify a specific negotiation process. Rather this paper's approach consists in identifying the basic building blocks of a group (i.e. holding firms placed in parallel or in cascade), investigating these building blocks' main properties and analyzing the reasons for combining these into complicated structures. Similarly, the findings in this paper do not require a detailed specification of the bargaining at time 1, except that only a party with negotiation power receives a share of the benefits. Furthermore, as capital constraints are to play an important role, this paper presumes that it is not possible to circumvent these constraints costlessly by cascading a sufficient number of publicly quoted holding firms. In particular, in conformity with empirical evidence, it is assumed that publicly floated shares of holding firms sell at a discount (see for example Gerson (1992), Siaens and Walravens (1993), Eurostaf (1992)). This discount comes on top of, and is different from the well known underpricing during an initial public offering. This paper presumes that this discount represents a real loss that firm owners wish to avoid. One reason why such a discount could arise, also in a rational world, is the impossibility of credible precommit towards the public shareholders (e.g. Gerson (1992)). If precommitment would produce a Pareto-improvement, the discount caused by lack of precommitment possibilities, represents a loss in welfare that firm owners bear. Other reasons can readily be found in the literature on closed-end funds. This paper's discussion also takes into account two more practical aspects: dynamic dimensions of the renegotiation problem (i.e. section 2.2. and 3.2. below) and some information issues (i.e. section 3.1. and 3.2.). Finally, in view of the importance of family corporate ownership in Europe, it should be remarked that the above problem could just as easily have been formulated in terms of a co-operation between family members.

1.2. The renegotiation problem and Continental European corporate law.

This section considers the main legal rules that turn holding firms, supplemented by shareholder syndicate agreements, into prime candidates for solving the renegotiation problem discussed above. In particular, generally there is a consensus in corporate law that three basic elements are necessary for a company to function: the company itself as a

separate legal entity, the board of directors and the shareholders.[3] In most Continental European countries (e.g. Belgium, France, Italy, Portugal, Spain, Luxembourg, Greece...), companies are governed by a one-tier board system. That is, one board of directors, chosen by the shareholders, monitors management. In some cases a two-tier board system is legally imposed on large firms (e.g. Germany, the Netherlands, Austria, Denmark and Sweden). This system features two boards with different tasks, and in one of them a minimal number of seats may be reserved for labor representatives (obligatory representation of labor occurs in Germany and the Netherlands).[4] This paper considers only one-tier boards. In this latter system, in Continental Europe, boards seats are usually assigned to the large shareholders, in proportion to share ownership (e.g. see Baums, Buxbaum, Hopt (1994)).[5] Furthermore, boards are also governed by the legally imposed 'ad nutum' principle, i.e. directors can be replaced by a simple majority vote of shareholders at any time. Deviating contractual or charter arrangements would be void (e.g. Belgium), or at least difficult to uphold in court (e.g. France).[6] In addition, large indemnity payments for early dismissal are not allowed either, as these would be considered an infringement on this principle. Clearly, for the precommitment problem of section 1.1., the at nutum rule excludes a simple cross-directorship as a viable solution to the renegotiation problem introduced above. Hence it should not come as a surprise that the main purpose of some of the constructions discussed in this paper is to circumvent this principle. The fact that the corporation is a separate legal entity also implies that most corporate forms are anonymous. In these forms, decision power is assigned to specific bodies, like the board of directors, or the general meeting. Therefore it is not possible to solve the precommitment problem by specifying in the corporate charter that, in case of event E_1 (E_2), the particular individuals M_X and M_1 (M_2) are to fix the distribution of B_1 (B_2). Nevertheless one can give a minority its say in a specific decision by including - next to standard super-majority rules imposed by the law[7] - special and possibly event-dependent super-majorities in the corporate charter (e.g. in case of event E a special super-majority is needed). In addition one may also include the requirement that board representation be

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[3] In some legal forms, tailored to the needs of small companies, not all of these three elements need to be present.

[4] French companies may also opt for the 'directoire', i.e. a corporate form with a two tier board.

[5] This contrasts sharply with the Anglo-Saxon world where boards usually are composed of insiders (members of management) and outside directors, and where neither type of directors necessarily represents large shareholders.

[6] See e.g. Byttebier (1993), Maeijer and Geens (1990), Campbell and Powers eds. (1993), Wymeersch (1994) in Baums and all). The only real exceptions to the ad nutum replacement principle occur in Germany and in the 'structure' corporate form of the Netherlands. In the 'directoire' in France the 'directoire'-tier of the board enjoys some protection against ad nutum dismissal (i.e. unless the director makes an error, dismissal entails the payment of an indemnity).

[7] The law typically imposes a super-majority for changes in the corporate charter (usually 75%); these legally imposed super-majorities are minimal requirements in the sense that firms may choose to make them more stringent (i.e. require, say, 90% instead of 75% for a charter change).

proportional to ownership. Putting special arrangements into the corporate charter has one major disadvantage though. As the contents of the charter and any subsequent adjustment has to be made public, special arrangements cannot be kept secret. Furthermore, also because of the anonymous character of the corporation, one cannot rule out the possibility of shareholders selling their stakes.

To solve - or at least alleviate - secrecy problems and difficulties caused by owners' inability to credibly precommit not to sell their shares, shareholder syndicate contracts are used. These contracts are private agreements between shareholders that may contain prepurchase clauses, stand still agreements, voting agreements (including possibly event-dependent special super-majority rules and agreements about the allocation of director seats) and indemnity clauses in case of breach of contract. The contents of these contracts does not have to be made public, and in some countries (e.g. Belgium), even their very existence may escape disclosure. However, at least for publicly quoted companies, the fact that such a contract has been concluded can be inferred from the disclosures required by the European transparency rules: whenever the fraction of shares owned by a party, or group of parties tied together by a syndicate contract, changes by more than a certain percentage, the transaction has to be made public.[89] However, syndicate contracts have one major disadvantage: this type of bond between participants is weaker than a bond realized through a corporate charter. That is, if it is prepared to pay an indemnity, a party can end the life of a contract by simply walking away from it (exaggerated indemnity payments would not be upheld by the courts). Conversely, because of its separate legal identity, the life of a corporation does not end if one of its shareholders walks away. However, notwithstanding the blow-up risk, voting agreements (including special super-majorities and the rules about the distribution of director seats) are typically laid down in these contracts rather than in the corporate charter, because of confidentiality reasons. Prepurchase clauses and stand still agreements are also part of these contracts because it would be hard to introduce them in the charter in a legally acceptable way.

One other feature in the European legal system that enhances the usefulness of holding constructions in solving the renegotiation problem of section 1.1. is the priority right attached to shares. This right assures that owners with a blocking minority can not be di-

[8] EC official publication journal, L 348, December 17, 88.

[9] Syndicate arrangements can take many different forms. The well documented agreement from mid September 1995 between the three controlling owners (i.e. Groupe Bruxelles-Lambert, Gemeentekrediet, Royale Belge) of Banque Brussel Lambert, the second largest commercial bank in Belgium, is a nice example of an event-dependent contract. Amid speculation about a possible sale of the bank, the agreement specified that the three owners set up a strategic committee to decide about the bank's future. The committee was to consist of seven members - representatives of the three owners - and decisions had to be anonymous (i.e. within the strategic committee it specified unanimity consent w.r.t. the 'event' strategic decisions). See Financieel Economische Tijd, 16/9/95 and 6/1/96.

luted against their wishes when new shares are issued. Finally the last (but not the least) consideration is the out of pocket costs of a solution. The use of a holding firm entails one time administrative expenses of incorporation (i.e. registration of the company), the cost of running a corporation (i.e. mainly maintaining the accounting system) and taxes. According to practitioners all of these costs can be kept to a minimum. In most cases costs of incorporation would be below 2% of the nominal value of share capital and, in principle, the administrative costs of running the firm could be kept to the equivalent of few thousand dollars a year. More importantly however, typically 85 to 95% of all dividends and sometimes also the capital gains holding firms realize, escape corporate taxes. Obviously, the out of pocket cost for concluding a syndicate contract is small.

In the analysis below, this paper presumes that, in accordance with observed practice, at time 0, large shareholders agree to allocate board seats among themselves proportional to ownership. In the constructions discussed below this implies that the decisions of the board of directors correspond to the choices of the general meeting if the latter would be called upon to decide on a particular issue.[10] Therefore, the analysis does not distinguish between the decisions of the board and the decisions of the general meeting. Furthermore, for expositionary purposes the discussion and consequences of the blow-up risk in syndicate contracts is postponed until section 4. Therefore, it is assumed until section 4 that proportional board seat allocation as well as non-standard super-majorities, are included in the corporate charter. Also for expositionary purposes, syndicate contracts are assumed to be used only when explicitly mentioned.

1.3. Holding firms as committees with veto power: an example

Suppose that initially no one faces binding capital constraints. Also assume that all parties agree to develop a precommitment tool by creating two parallel holding firms H_1 and H_2. M_X endows these holding firms with some of its X-shares. Simultaneously, it sells blocks of X-shares to M_1 and M_2, with a clause that these shares should be transferred into the holding firms. For concreteness, suppose that M_X sells M_1 and M_2 each a block of 15% in X. At the same time it endows holding firms H_1 and H_2 respectively with an additional 20% and 25% of all X-shares (this to illustrate that symmetry is not a requirement for the solution). Hence as depicted in figure 1 below, after the transaction, H_1

[10] In some countries (e.g. France, Belgium) the directors representing a particular block holder have to leave the board meeting when an issue that is of particular interest to this block holder is voted. However as this regulation does not encompass the general meeting (i.e. the body ultimately approving all decisions), one may not expect it to have much impact whenever the large block holder has enough voting power at this meeting (in the ownership constructions discussed below this will always be the case).

owns 35% of company X, while M_X owns (20/(20+15))*100 = 57% of H_1. Similarly H_2 owns 40% of company X and M_X holds 62.5% of H_2.

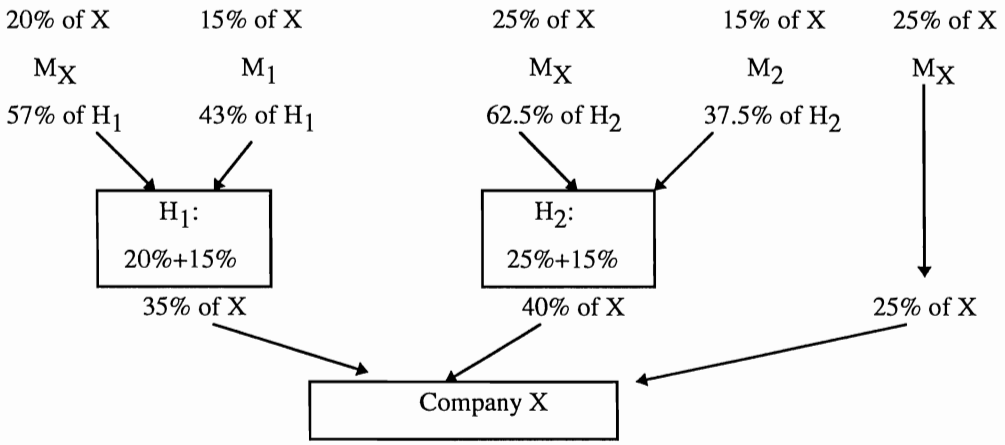

Figure 1

The top row denotes the percentage of X's equity that M_X, M_1 and M_2 have put into a particular channel of ownership. The percentages shown below M_X, M_1, M_2, H_1 and H_2 denote the fraction of ownership in the firm next down the chain. The sums in the rectangles surrounding H_1 and H_2 indicate how the holding firm's ownership in company X is distributed. To complete the construction, M_X and M_1 include in H_1's charter an appropriate super-majority (e.g. 75%) conditional on event E_1 (that is, as long as event E_1 is not active, H_1 is governed by simple majority). A similar arrangement is made in H_2 but then conditional on E_2. Finally, M_X introduces an appropriate super-majority in company X (e.g. 70%). This super-majority may be general or dependent upon events E_1 and E_2.[11] Clearly, for any decision other than those concerning E_1 and E_2, shareholder M_X can push through its decisions in company X. For M_X controls H_1 and H_2 and, furthermore also owns the remainder of the X shares not tied up in the holding firms. However, for anything related to event E_1, M_X needs the approval of M_1. In particular, whenever M_1 does not agree with M_X's proposition about the distribution of B_1, M_1 can block the proposal through the holding firm H_1. For M_X could maximally get 65% (= 25% + 40%) yes-votes for any proposition not carrying M_1's consent. Obviously this does not meet the super-majority requirement in firm X. Furthermore M_2 has no power in holding firm H_2 as long as event E_2 is not active. Thus M_2 can not force any decision concerning B_1 on M_X and M_1. Hence, M_1 can block the distribution of B_1 in firm X. However it cannot stop M_X from consuming B_X, nor, as readily shown by a similar analysis w.r.t. M_2 and E_2, can it stop M_X and M_2 from consuming B_2. In short M_1 can block proposals about B_1 and only about B_1. Furthermore, the example shows that, when

[11] Unless explicitly mentioned otherwise a super-majority is always assumed to be non-event-dependent.

an appropriate ownership structure in firm X is combined with a suitable super-majority, the pivotal position a co-operator enjoys in its holding firm, carries over to company X. This carry-over logic underlies all holding firm and ownership structures discussed in this paper. In addition it is also interesting to note that the example's enforcement device precommits M_X to take the preferences of M_1 (M_2) into account in all of firm X's strategic decisions linked to E_1 (E_2). Hence, if the issues related to E_1 (E_2) are strategically important to M_X, the latter may also demand a similar enforcement arrangement in the firm of M_1 (M_2). Obviously this can only add to the intricacy of observed ownership patterns.

The solution of figure 1 essentially serves the purpose of circumventing the precommitment problems created by the ad nutum principle from section 1.2.. It is shown in section 4 below that in such a case, an alternative solution may be more efficient, at least if the benefits B_1 (B_2) are not too substantial. This is not likely to be true anymore if the example is modified to encompass binding capital constraints. In particular, referring back to the above example, assume now that the co-operations require important investment outlays, and that M_X is confronted with a binding capital constraint. As M_1 and M_2 have some spare financial resources available, they are prepared to purchase each 30% of the shares of X.[12] Clearly this operation would land M_X in a minority position, so that every one could be ripped off if the two other parties decide to collude. This two-sided renegotiation problem can be solved by modifying the holding structure as shown in figure 2:

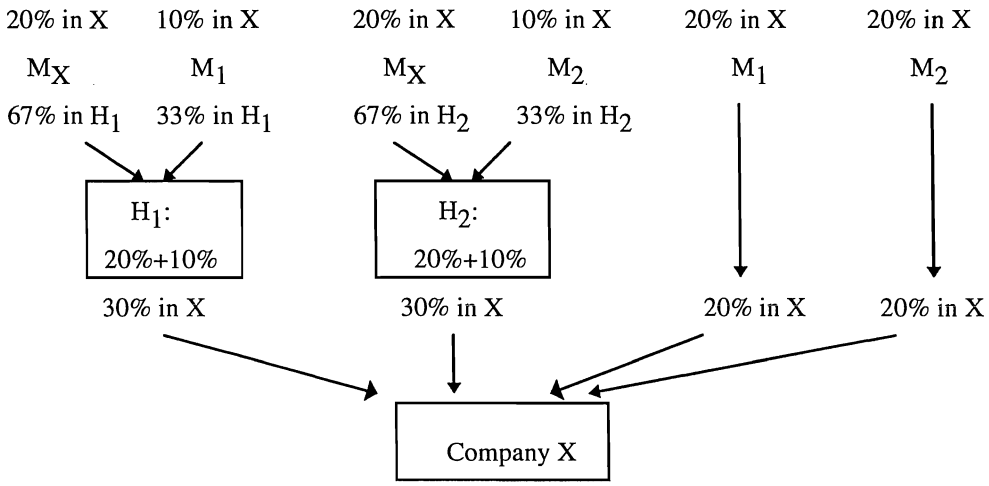

Figure 2

[12] Alternatively, M_X could create a vertical cascade of publicly quoted holding firms on top of company X to deal with its capital constraints. In that case M_1 and M_2 could stick with their 15% block, as in the initial situation. However, if M_1 and M_2 have spare capital available the solution proposed in the text is preferable because it avoids the discount on the public floatation of the holding firm shares. This benefit could be shared between M_X, M_1 and M_2.

As before, an event specific super-majority is introduced into the charters of the holding firms H_1 and H_2. However in company X, the standard majority of 50% is used. It is easy to see that notwithstanding its reduced (direct and indirect) ownership position, M_X still keeps general control. Furthermore, whenever event E_1 (E_2) is concerned, M_1 (M_2) has a pivotal position in H_1 (H_2). It is also easy to check that, just as in the problem of figure 1, these pivotal positions carry over to firm X. The solution in figure 2 shows one more crucial property of the holding construction: next to solving M_1 (M_2)'s problem w.r.t. the distribution of B_1 (B_2), it also puts a stop on unwarranted recoalitioning that could affect pivotal positions. In particular, although (directly and indirectly) M_1 and M_2 own 60% of the shares, they cannot form a coalition against M_X because the holding structure separately 'glues' M_1 and M_2 to M_X; neither can M_1 and M_X form a coalition against M_2, nor can M_X and M_2 collude to rob M_1.[13] Nevertheless some residual renegotiation problems may remain. For example, B_1 (B_2) may depend not only upon the project, but also upon the quality of the participants in a particular venture. Hence if M_1 (M_2) would sell out ex-post, this could influence B_1 (B_2) and hence the amount of benefits M_X receives at time 1. In view of the unobservability of benefit production to outsiders, the buyer is likely to be M_X or M_2 (M_1), at least if the latter would be capable of observing benefit production in a co-operation in which it is not involved in.[14] Obviously, to limit such problems, participants could use protective prepurchase agreements. Furthermore, to make a sale by M_1 (M_2) to M_2 (M_1) more costly, also stand still arrangements could be concluded. In fact, M_X may wish to watch especially closely agreements between M_1 and M_2. In particular, if M_1 (M_2) sells part of its stake to M_2 (M_1) and vice versa, so that both are simultaneously pivotal in case of events E_1 and E_2, M_1 and M_2 have a credible precommitment to tie the negotiations about the distribution of B_1 and B_2. This could result in a different benefit distribution from the one in which M_1 and M_2 negotiate independently with M_X. However such tying need not occur. For one thing, general negotiation conditions may be such that tying may not increase M_1's and M_2's negotiation power at time 1. In addition, stand still and prepurchase clauses may make such tying prohibitively costly. Furthermore if M_1 (M_2) cannot observe B_2 (B_1), such behavior becomes unlikely. Finally, M_1 and M_2 may be competitors in the area of their co-operation so that they may not wish any interference from the other party. Similarly, tying policies do not necessarily benefit M_X. Because of these reasons, and

[13] M_X could save on the creation of one holding firm at the expense of a more complicated decision structure in firm X. In particular M_X could form a holding firm H_1 with M_1 in which both transfer all of their X-shares. M_2 keeps its direct stake of 30% in firm X. If firm X is equipped with an event-dependent super-majority (e.g. 80%) conditional on E_2, and governed by simple majority otherwise, the structure also solves renegotiation. This asymmetric solution and its generalization to N co-operations does not yield insights different from the symmetric case discussed here and in the following section.

[14] A sale to an outsider would presume that this outsider could obtain information.

because of the fact that they do not destroy the pivotal equilibrium (i.e. no party can be robbed from its pivotal position against its wishes), one may generally expect the above 'second order' renegotiation games to have a limited effect on benefit sharing. Nevertheless, the discussion above offers a rationale for the use of prepurchase clauses and stand still agreements, i.e. they reduce residual renegotiation opportunities.

The solutions corresponding to figures 1 and 2 have important properties in common; they also have implications for empirical research. In both solutions a multi-holding group is created, where the holding firms placed on top of firm X serve as a device to structure decision power over the latter company. In particular, although in comparison with the initial situation in which M_X owns 100% of firm X, major changes in company X's ownership structure have occurred, there has been little change in the general control over firm X. Notwithstanding the fact that M_1 and M_2 have become (directly or indirectly) important block holders, their exercise of control and monitoring is limited only to a specific activity of company X. General control and monitoring remains with M_X. As shown in section 3.1. below, the phenomenon of 'limited interest' block holders is even further enhanced by capital constraints.[15] This specialization-of-interest-representation in holding structures contrasts sharply with the dominant view in the finance literature, which presumes that all large block holders participate in general monitoring and control. Consequently, because of their 'limited interest', block trading by minority owners like M_1 and M_2 may not have an important impact on firm X. The limited scope of block trading by holding firms may be even further enhanced by the European take-over legislation. In particular, one would expect that a sale by owners with general control tasks involves large blocks if 'specialization-of-interests' plays an important role in holding structures. However European take-over legislation requires the buyer to launch a public bid if an important change in control takes place through block trading. Although the trigger conditions may differ from country to country, a common ingredient in the rules is that the size of the traded block should be sufficiently important.[16] Consequently, when holding structures are involved, block trades that could have an important impact, may take the form of a public bid. The findings of Leleux, Vermaelen and Banerjee (1995) are consistent with the above view. In their sample of non-controlling stake purchases in French listed companies, these authors find that stakes purchased by holding companies generate non-significant price reactions in target firms, compared to significant price reactions for other acquirors. Furthermore, managerial turnover in target companies follow-

[15] In Belgium and France, practitonners refer to this phenomenon as 'le système de l'actionnaire de référence'. It means that one important block holder or a limited subset of block holders exercise general control.

[16] A change in control sufficient to warrant a take-over bid, may be a matter of appreciation by the supervising authorities (e.g. in Belgium), or be triggered automatically by exceeding a certain ownership limit (e.g. 33.33% in France).

ing the block trade is lower when the buyer is a holding firm. Both results indicate less active involvement in management by holding firms-bidders as compared to non-holding firm bidders.

Concerning the structure of holding groups, figures 1 and 2 show inter-group sharing of holding firm ownership, and possibly also some inter-group sharing of ownership in firm X. By contrast, no direct (cross) ownership ties between the holding firms of the same group are present. If these results could be generalized, the analysis above predicts the emergence of simple horizontal holding groups with inter-group ties but little intra-group ownership between the groups' holding firms. Hence, as it is natural to expect that a simple structure is preferred to a complicated one, the current solution is incomplete. What is still lacking is an explanation for the intricate intra-group ownership structure of large holding groups. Furthermore also the dynamic renegotiation aspects need investigation (i.e. participants may attempt to change the holding construction itself or its properties). The next section generalizes the above examples to N co-operations with possibly many parties per co-operation and analyzes the problem of structural changes. Complicated intra-group ownership is discussed in section 3.

2. THE CASE OF N PARALLEL HOLDING FIRMS

2.1. The structure with N co-operations

Appendix B considers the conditions under which the renegotiation problem could be solved through a parallel holding group structure with $N \geq 2$ co-operation opportunities and possibly many outside parties M_j ($M_j \neq M_X$) per co-operation. It turns out that a parallel holding group solution exists whenever M_X is not facing too severe capital constraints. Proposition 1 below concerns N co-operations with disjoints sets of n symmetrically treated M_j per co-operation. It shows the minimal direct and indirect ownership in firm X that M_X has to maintain for a parallel holding solution to exist. Simultaneously it also indicates the corresponding ownership positions of outsiders and the required supermajorities.

Proposition 1: The minimal <u>total</u> indirect ownership proportion in company X that M_X needs to maintain to form N holding firms with n outside parties in every holding firm is equal to $[(N - 1)/(2*N)]$.[17] Furthermore M_X does not keep any direct ownership in firm X

[17] i.e. in percentage terms ((N-1)/2N)*100. The fact that, next to the required (super) majority, one more vote is necessary to push through a decision, is for simplicity not taken into account in the results reported in the proposition. The proof in the appendix encompasses marginal additional vote requirements.

while the direct ownership of any M_j amounts to $[1/(N^2*n)]$. This solution requires a super-majority of [(N - 1)/N] in company X. It also requires that M_X keeps 1/2 of the ownership of every holding firm, with the remainder distributed evenly over the n participating M_j. Finally, event-dependent super-majorities within every holding firm may vary between (1 - 1/2*n) and unanimity.

Proof: see appendix B

Proposition 1 shows that the parallel holding solution has a number of drawbacks. First, it is easy to see that M_X's minimal indirect shareholding (N-1)/(2*N) is increasing in N. This implies that with parallel holding firms, more co-operations put additional financial pressure on a capital-constrained M_X. Hence, whenever M_X cannot maintain the minimal ownership required by a parallel holding solution, a different type of structure becomes a necessity. Second, if M_X wishes to avoid special arrangements in firm X, maximally two holding firms placed in parallel may share direct control over company X. In particular, proposition 1 implies that the only co-operation problem that could be solved through parallel holding firms with a simple majority in firm X is one with two co-operations, i.e. (N - 1)/N = (2 - 1)/2 = 0.5. Finally note for further reference that in proposition 1, a capital-constrained M_X does not keep direct ownership in firm X. The reason is that for every additional share of firm X that M_X places in a holding firm that it marginally controls, an outsider can add one share also without endangering M_X's position. However in the solution of proposition 1 all of the X-shares owned by this holding firm help M_X in maintaining general control over firm X.

2.2. The problem of structural change ex-post

The issue of structural change ex-post contains two interesting aspects: the problem of M_X adjusting the structure ex-post to rob the M_j from their pivotal positions, and the problem of integrating new co-operation opportunities. The importance of the former issue is obvious: if such opportunities were available, the above proposed precommitment device would disintegrate. The second aspect also has importance in a changing world. What is at stake is whether or not in a holding structure that protects outsiders against 'bad' changes, there is still room for the integration of new opportunities, i.e. 'good' adjustments. Clearly if M_X would always have to ask the consent of the outside parties, the latter could demand side-payments. Especially if many outsiders are represented in the holding structure, this type of renegotiation opportunities could become an important problem.

Concerning the problem of 'bad' changes, the M_j understand that, without appropriate protection, in the above parallel holding solution, M_X retains the opportunity to undo pivotal positions, by changing the holding group structure or the super-majority rules ex-post. The list of 'bad' games against which rational M_j demand protection is the following one:

- Game A: liquidation of some H_i. After setting up of the structure, M_X may suddenly decide to dissolve a holding firm to rob the other participants of the co-operation from their pivotal status. To rule this out, holding firm H_i should be endowed with an additional super-majority that turns all the participating M_j into pivotal players for the liquidation decision. Alternatively, and more straightforward, the holding firms' event definitions could be extended to include liquidation.
- Game B: sale of shares by some H_i. M_X, being the majority owner of H_i, could destroy the pivotal positions of its co-owners by selling H_i's ownership in firm X to a new holding firm $H_{i_\S}$ placed in parallel to H_i. Hence the M_j would rationally demand veto power over any sale of firm X's shares by H_i that could destroy H_i's pivotal position. Again, this could be solved by extending the event definitions. Alternatively, direct ownership positions of the M_j in firm X could be used as the basis for prepurchase clauses in a syndicate agreement between the owners of company X.
- Game C: a change in the super-majority rules of holding firm H_i or firm X. Obviously rational M_j demand veto power over a change in the super-majority rules governing their holding firm and firm X. On the level of the holding firms, this problem could be resolved by an extension of the event definitions. On the level of company X, some direct ownership in firm X by the M_j, combined with an appropriate super-majority in X's charter, would do the trick.

When negotiating about the structure of the holding group at time 0, a rational M_X would take into account the ease with which it could ex-post incorporate new opportunities, at least if there was a possibility for such an occurrence. In particular, a holding group would be lacking structural flexibility when M_X would need the consent of (at least some of) the M_j for integrating additional co-operations. Hence the question: does a parallel holding structure offer flexibility if it is equipped with minimal protection clauses that are just sufficient to rule out the above games ? Returning for simplicity to the case of figure 1, it is straightforward to see that its direct ownership in firm X, allows M_X to form a new 'committee' by the familiar procedure of selling some of this 25%-block to a new co-operator M_3, and creating a new parallel holding firm H_3. Moreover if in the initial structure M_X would have supplemented firm X with a super-majority that also makes its block of 25% pivotal (e.g. 80%), no adjustments requiring the consent of M_1 and M_2 would be necessary. More generally, M_X could initially create N parallel empty commit-

tees (i.e. holding companies fully owned by M_X) that are all pivotal in the decision making of firm X. To realize this, M_X does not actually need to set up N holding companies. Obviously keeping directly the X-shares that would be transferred into these firms suffices. However according to proposition 1, a policy of keeping direct ownership is not efficient for M_X in terms of capital uses. Furthermore, as proposition 1 also implies that more co-operations consume more of M_X's financial resources, it follows that in a world with capital constraints, parallel placements have most chances of occurrence in situations with few co-operations among an unchanging set of partners, and if, as noted in section 1.3., the benefits of the co-operation are substantial (i.e. as indicated there, otherwise alternative solutions may be more efficient). In the latter case it is also natural to expect that M_X demands to be pivotal in the firm of the co-operator as well (see also section 1.3.). Well known examples of companies that use two parallel holding firms as a tool of mutual enforcement in a long standing and substantial co-operation, are the large Dutch-British groups Shell (a combination of the Royal Dutch Oil company and the Transport and Trading Company) and Unilever (a combination of Dutch Unilever and British Unilever).[18] Also in private firms with second or third generation family ownership, control is sometimes organized through parallel holding firms.

3. HOLDING SYSTEMS AND TWO-SIDED CAPITAL CONSTRAINTS

This section shows that two-sided capital constraints enhance inter-group ownership links. Furthermore, these constraints are also likely to cause intricate intra-group ownership patterns. In particular, the first subsection offers a rationale for the varying size in the blocks that different outsiders may own in the same holding company. The second subsection discusses cascading of holding firms that are used for enforcement.

3.1. The market for soft information and non-pivotal shares

Reconsider the problem of figure 2 but now suppose that next to M_X also M_1 and M_2 face capital constraints. Neither M_1 nor M_2 can afford to sell any of their direct ownership in company X, as such a sale would result in a loss of their pivotal position. Clearly, this capital constraint problem could be solved by the creation of non-pivotal ownership blocks that could be sold without upsetting the equilibrium. Without changing the structure proposed in figure 2, some of the equity can be made non-pivotal by an appropriate definition of the super-majorities. For example, suppose that in holding firm H_1 the event specific super-majority would have been set at 83.5%. Then M_1 could reduce its owner-

[18] The issue of organizing long term co-operations either by parallel placement of holding firms, or by outright merger, or by a new still to be created specially tailored European legal form, is a matter of ongoing debate in the law literature (e.g. see Honée (1991), Byttebier (1994)).

ship in holding firm H_1 from 33% to [100% - 83.5%] = 16.5% without endangering its super-majority protection.[19] Similarly, also in H_2 some of the shares could be made non-pivotal. This of course presumes there are buyers for these ownership blocks. In practice, these blocks could be sold for the soft information exchanged at board meetings. Furthermore the personal contacts at these meetings could result in mutual beneficial opportunities. These objectives could be realized by providing outsiders-smaller-block-holders with non-pivotal director seats (for the impact of soft information and owner representation on firm policy, see e.g. Francis and Smith (1995)).[20] Moreover, the discussion in the above sections implies that each holding firm H_i has its specialization centered around its own co-operation activity. Consequently each holding firm may have its own specific soft information to sell.

Proposition 2: Reconsider the solution of proposition 1. Within any holding firm that governs company X, the maximal proportion of non-pivotal holding firm shares is equal to 1/[2*(n+1)]. It is obtained when M_X's ownership proportion amounts to 0.5 and the event-dependent super-majority is equated to [1 - 0.5/(n+1)]. On the level of the ownership of company X there are no non-pivotal shares.[21]

Proof: see appendix C

One surprising consequence of proposition 2 is that large variation in the size of the ownership blocks of a holding firm may be compatible with a symmetrical solution to the renegotiation problem in co-operations: the large blocks represent owners with veto power and the smaller ones may represent purchasers of soft information. The proposition implies that the proportion of non-pivotal shares per holding firm dwindles quickly as the number of participants per co-operation (i.e. M_X and n M_j) increases.[22] Since the buyers of these smaller stakes may be under capital constraints themselves, what may be needed is a holding group structure that allows for raising large amounts of non-pivotal capital in the stock exchange.

[19] To be fully accurate, M_1 could reduce its ownership in holding firm H_1 to (16.5% + 1 share).
[20] In a model that would aim at deriving explicitely an optimal holding group structure, the sale of soft information could be included by assuming that such a sale increases the probability of future new co-operation opportunities with a certain factor.
[21] Just as in proposition 1, the fact that, next to the required (super) majority, one more vote is necessary to push through a decision, is for simplicity not taken into account in the results reported in the proposition. The proof in the appendix encompasses marginal additional vote requirements.
[22] The proportion of non-pivotal shares summed over all N holding firms (i.e. N/2*(n+1)) increases in N.

3.2. Capital constraints as generators of intra-group ownership

Sufficiently strong capital constraints on M_X necessarily lead to direct ownership ties between the holding firms of the same group. In particular, proposition 1 implies that if M_X is not capable of maintaining a majority position in all holding firms H_i, parallel placement of these companies is an infeasible solution to the renegotiation problem. Furthermore, if scarcity of capital is also an issue for the co-operators, in a major way additional shareholders (i.e. the public) may be needed to support the financing of firm X. In view of the supplementary discount on holding firm shares, the least cost solution would be the one where the equity of company X is publicly floated.[23] In that case the simplest construction that maintains the pivotal equilibrium, places the 'enforcement' holding firms in cascade. In particular, suppose that in the problem in which M_X organizes a co-operation with M_1 and M_2, the three parties opt for cascading holding firms $H_1$and H_2. For concreteness, suppose that M_X sells M_1 and M_2 each a block of 17%, under the condition of subsequent transfer into the holding firms. Then M_X places 18% of the X-shares in H_1 and M_1 adds its block of 17%. In turn H_1 transfers this ownership into H_2. Next also M_2 transfers its block of 17% into H_2. Finally, the remainder of firm X's shares is sold to the public. This structure is graphically represented in figure 3 below:

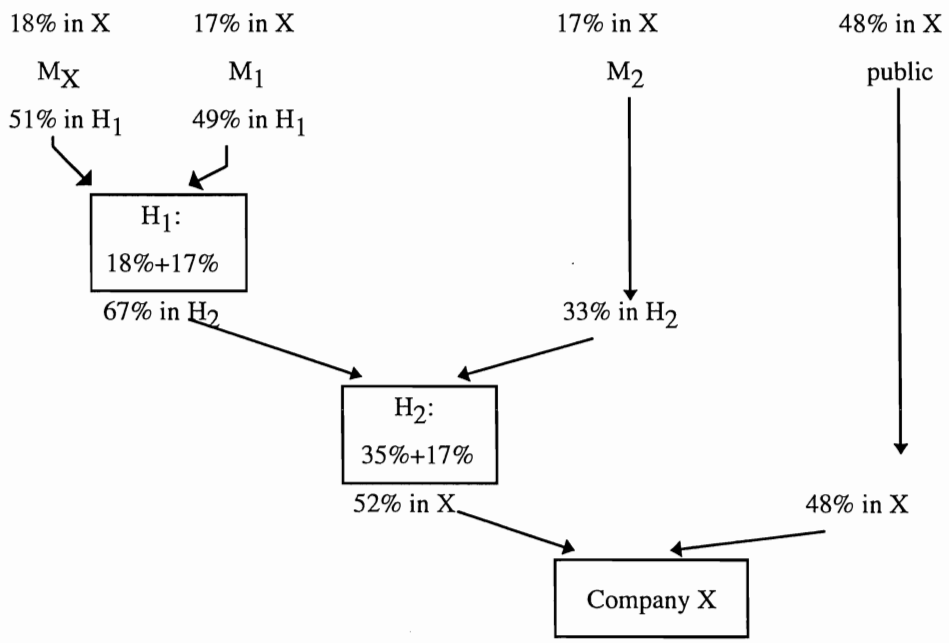

Figure 3

[23] Only if this operation would not enable these three parties to design the sought for decision power structure, public floatation of holding firm shares would take place.

To complete the solution, holding firms H_1 and H_2 are subjected to an event-dependent super-majority, conditional on E_1 respectively E_2, while firm X remains governed by a standard simple majority. Just as in the case of parallel holding firms, M_1 (M_2) can block any decision of firm X in the area of its co-operation. In particular, if E_1 occurs and M_1 does not agree with M_X's proposal, it can block H_1. Since H_1 has a majority in H_2, that in turn has a majority in firm X, the latter company is blocked also. A similar argument holds true for M_2. The present solution shares with the previous parallel placement constructions, the specialization-in-interest property and the occurrence of inter-group ownership. However there are also some significant differences. In particular, figure 3 illustrates that cascading readily turns large fractions of equity into non-pivotal stock. That is, the votes of the 48% X-shares placed in public cannot disturb the enforcement equilibruim between M_X, M_1 and M_2.[24] Furthermore, contrary to the case of parallel placement, with cascading more co-operations relieve a capital-constrained M_X. In addition, the present structure has the advantage that no special super-majorities are required in firm X.[25] Hence, as this solution is both simple and cost efficient, the question arises why capital-constrained holding groups often do not show a pure vertical intra-group structure. In view of the discussion in section 2.2., the first explanation that comes to mind is structural inflexibility caused by protection clauses for minority owners. For not only do co-operators need protection for the bad structural games listed in section 2.2., in the case of cascading they also need protection for an extension of games A and B:

- Game $A^{\S}$: liquidation of some holding firm lower in the chain. In particular, in the problem of figure 3, M_X and M_2 could agree to rob M_1 from its share in the benefits B_1 by dissolving holding firm H_2, and replacing it by another holding firm $H_{2_{\S}}$, placed in parallel to H_1. Suppose this occurs after M_X has found a way to circumvent its capital constraints (e.g. costly public floatation of a newly created holding firm, sale of assets,...) so that M_X can launch a take-over bid on the 48% of company X's shares. Holding firm $H_{2_{\S}}$ then receives all shares bought from the public and the 17% shares of M_2 (in return for its co-operation M_2 receives the protection of a super-majority clause for event E_2 in holding firm $H_{2_{\S}}$ plus possibly some other advantages). Clearly, with its majority of 65% (= 48% + 17%), $H_{2_{\S}}$ has destroyed H_1's pivotal position. Such a procedure could be quite costly for M_X: next to suffering the discount on the public sale of holding firm shares, M_X may also have to pay a take-over premium. Still M_1 may wish to be protected against it. Obviously M_1's problem is solved if it obtains veto power over the liquidation decision of H_2. This could be realized by providing M_1 with some shares in H_2 and by inserting an appropriate super-majority w.r.t. liquidation in H_2's charter. Loss of

[24] Contrary to the Anglo-Saxon tradition, in Continental Europe a parent company does not have to maintain an arm's length relationship with a publicly quoted daughter.

[25] The ownership conditions for a cascade system with N co-operations and pivotal properties is given in appendix C.

pivotal position through holding firm dissolution cannot hit M_2. Whatever happens higher up the chain, holding firm H_2 in figure 3 continues to have majority control over company X, and no matter who is the majority owner of the shares of holding firm H_2, the super-majority in H_2 requires M_2's consent in case of event E_2. Clearly in the N holding firm case, the enforcement solution requires that every M_j has veto power over the liquidation of holding firms lower in the chain.[26]

- Game $B^{\S}$: sale of shares by some holding firm lower in the chain. If in the problem of figure 3, M_X and M_2 could agree to transfer H_2's shares in firm X into a new holding firm $H_{2_{\S}}$, M_1 would be robbed from its pivotal position. To stop this it is sufficient that M_1 obtains veto power over pivotal block transfers in H_2's ownership of firm X. More generally, in the N holding firm case, the enforcement solution requires that every M_j has veto power over trade of pivotal blocks of shares owned by holding firms lower in the chain.

However the above games need not cause structural inflexibility. In particular, in a holding group with protections that rule out all of the above games, M_X could still transfer its ownership in H_1 into a new holding firm H_3 (placed on top of H_1) and sell some of the ownership to a new co-operator M_3. As this transaction does not endanger the pivotal positions of M_1 and M_2, it is feasible in a fully protected structure. To assure that it can provide the new co-operator with protection against the bad games described just above without having to depend upon the agreement of M_1 and M_2, M_X could have arranged that it may transfer non-pivotal proportions of the assets of the holding firms (i.e. such transfers do not allow M_X to play bad games). Alternatively, in the initial set up, M_X may already create 'empty' and fully protected committees in the chain. All this implies that structural inflexibility reasons do not necessarily explain deviations from a pure cascade structure.

Nevertheless capital constraints and use of cascaded holding firms as enforcement devices, create conditions under which deviations from the simple structure of a single (long) holding firm line are likely to arise in practice:

A. Difficulties for the co-operators M_j to get their preferences implemented in firm(s) X. One may expect that in practice, at each node some of the information contained in the messages from the holding firms higher up in the chain is lost or distorted, especially as

[26] As an alternative solution, M_X could extend the event definitions to include liquidation decisions in every holding firm down the chain. Finally, a third way to ease H_1's renegotiation worries is a syndicate agreement containing prepurchase clauses and stand still agreements among the owners of holding firm H_2 (the latter clause is needed to stop M_X and M_2 from playing the take-over trick). However, again M_1 must be made a party to this contract; otherwise, just as for the dissolution decision of holding firm H_2, M_X and M_2 may simply agree to discontinue the contract (see also the discussion in section 4 below). All this implies that in a structure with cascading, smaller block holders may represent purchasers of soft information as well as owners with a pivotal position w.r.t. liquidation.

these messages have to reflect the preferences of an increasing number of parties as one moves down the chain.[27] This problem is likely to become especially important if the holding group controls several non-holding firms. Hence it is natural to expect that otherwise too lengthy control lines are shortened by combining cascading with parallel placement.

B. Deviations caused by loss of soft information. Next to the M_j also M_X may be affected by the loss of information in the chain. This may be particularly problematic as M_X exercises general control. Consequently, to receive the soft information exchanged at firm X's board meetings or at the board meetings of some holding firms down the chain, M_X may take a direct participation in those firms (section 3.1. implies that M_X can do this ex-post without upsetting the enforcement equilibrium as long as its direct ownership block is non-pivotal). To ascertain an exact implementation of its preferences, M_X may even find it important to be directly present in some firms down the chain with a pivotal position. Consequently, if the pivotal positions of the other participants are to be maintained, generally some deviation of pure cascade in the initial set up will be required.

C. Deviations caused by stringent capital constraints. A very efficient way in which, through time M_X can save capital in a set up like figure 3, is have the bottom holding firm H_2 accumulate the dividends from firm X to repurchase some of M_X's shares in holding firm H_1. It is easy to check that the resulting cross ownership does not affect pivotal positions, and hence does not disturb the renegotiation-free equilibrium ex-post.[28] More generally, M_X can use cross and circular ownership in the initial set up of the structure and/or introduce it afterwards to save on capital without upsetting the enforcement mechanism. Furthermore, cross ownership between lines of parallel holding firms could also have positive effects on information streams across these lines. However it should be mentioned that, although it has not been ruled out entirely, M_X's opportunities to use vertical cross ownership have been drastically reduced since the introduction of the second EC directive (article 24a) that limits such ownership to maximally 10% of the votes of share capital.[29]

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[27] This can readily be incorporated explicitely in the model by assuming for example that the range of events E_i (and consequently also the portion of B_i over which the M_j have veto power) 'shrink' as the length of the chain below these M_j increases.

[28] Nevertheless it imposes opportunity costs on M_1, M_2 (M_3) as the dividends that otherwise could have been paid out are now used to ease M_X's capital constraints. The same problem may also occur in the structure with parallel holding firms. M_X can be stopped if the use of a holding firm's accumulated cash is made part of the event definitions (i.e. by dealing with this opportunity cost the solution is being extended to encompass the distribution of security benefits).

[29] EC official publication journal, L 347, November 28, 92. This directive only limits vertical cross ownership. However some countries (e.g. Belgium) have extended this limit to encompass horizontal cross ownership also.

4. ALTERNATIVE SOLUTIONS

To explain the holding structure as a rational response to renegotiation problems, it does not only have to be an effective and cost efficient solution, but it also has to be the best of all available alternatives. This section shows that other solutions are likely to be either unsuitable or ineffective.

4.1. Shareholder syndicates[30]

Although currently Continental European courts uphold syndicate contracts, this has not always been the case (e.g. in France, see Byttebier (1993), Maeijer and Geens (1990)). Moreover, in the past, these agreements, or certain components, were sometimes also limited in time. For instance, in Belgium, until 1993, syndicate contracts could be concluded for an indefinitely long time period, but their voting agreements had to be renewed every 5 years. Generally, over the last several years, Continental European law and court decisions have been changing in favor of syndicate agreements. If this trend continues and also encompasses court support for high penalties on breach of contract, these agreements may more easily replace holding firms. For example, imagine that in the problem of figure 2, as before, M_1 and M_2 would each buy 30% of firm X's shares. However, the three parties would conclude a syndicate contract instead of creating the holding firms H_1 and H_2. Suppose this contract would encompass the following arrangement:

Decisions may be taken by mutual consent of M_X, M_1 and M_2.

Disagreement triggers the following procedure:

A. Disagreement does not concern events E_1 or E_2. Then a decision requires majority support where M_X, M_1 and M_2 receive respectively 60%, 20% and 20% of the votes.

B. Disagreement concerns event E_1. Then a decision requires a super-majority of 80% while M_X, M_1 and M_2 receive respectively 50%, 40% and 10% of the votes.

C. Disagreement concerns event E_2. Then a decision requires a super-majority of 80% while M_X, M_1 and M_2 receive respectively 50%, 10% and 40% of the votes.

Clearly the above agreement perfectly mimics the pivotal positions of M_X, M_1 and M_2 in the holding solution of figure 2. Unfortunately, since any change in a contract typically requires the consent of all parties involved, the syndicate agreement only mimics inflexible holding structures. Hence, if flexibility is important, syndicate contracts without

[30] Until now syndicate contracts were discussed from the perspective of how these contracts support the holding solution. In this section it is shown that under certain circumstances the voting agreements of a syndicate contract can be used as a substitute for a holding construction.

blow-up risk could still not replace the structure of a holding group. Nevertheless if the trend of contract strengthening continues, one may expect to see holding groups 'simplify' as some holding firms are replaced by a syndicate agreement.

Another issue that needs clarification, is the reason why in practice, one creates holding firms and simultaneously places all the rules governing voting (i.e. distribution of director seats, special super-majority arrangements) in syndicate contracts. As a chain is only as strong as its weakest component, one may wonder why one does not simply opt for the syndicate contract solution discussed just above. However, this policy of combining holding structures with syndicate agreements becomes quite understandable if one notes that, by placing holding firms in between the syndicate contract and company X, the incentives for walking away from the agreement may be reduced. In particular, reconsider the problem of figure 2, and suppose for a moment that the holding firms H_1 and H_2 would be replaced by a syndicate contract between M_X, M_1 and M_2. In that case M_X would directly own 40% of company X while M_1 and M_2 would each own 30%. If this arrangement would mimic the holding structure of figure 2, it would assign M_X all of the control benefits B_X of company X (i.e. other than B_1 and B_2) plus a share of B_1 and B_2. Clearly, M_1 and M_2 would have a strong incentive to collude against M_X and walk away from the contract. In particular, by blowing up the contract, a colluding M_1 and M_2 would share majority ownership over firm X, while M_X would be left in an unprotected minority position. Clearly in that situation, M_1 and M_2 could pocket B_1 and B_2 and on top B_X. If, as assumed in section 1.1., B_X is much more important than B_1 and B_2, only a large indemnity could stop a rational M_1 and M_2. However when, as in figure 2, the three parties opt for the solution with holding firms and non-standard arrangements included in syndicate agreements, M_X would gain by walking away from these contracts.[31] For this action reduces M_1's and M_2's ownership to a weak minority position. However this move would yield M_X only limited additional profits: all M_X could gain by blowing up the syndicate agreements in both holding firms H_1 and H_2 is M_1's and M_2's share in B_1 and B_2. Clearly the syndicate contracts on top of the holding firms H_1 and H_2 are much easier to maintain than the syndicate agreement without the holding firms.[32] Repeating the analysis for the problem of figure 1, it is easy to see that there the holding

[31] Note that if the pivotal equilibrium solution with the holding firms requires a special super-majority in company X, also a syndicate contract is needed among the owners of company X. Here again the renegotiation problem due to dissolution of the syndicate contract binding the owners of company X may lurk around the corner, unless the parties in the top holding firms are made part of the agreement. If M_X wishes to avoid this, it may design a structure in which the pivotal equilibrium may be sustained without any super-majority in X. As remarked earlier, proposition 1 implies that a parallel holding solution can be sustained by simple majority in company X if maximally 2 holding firms share direct control of firm X.

[32] Furthermore, the fact that holding structures in combination with syndicate agreements offer M_X benefical blow-up possibilities, is likely to function as an additional stick behind the door if M_1 and M_2 would contemplate playing the residual tying game discussed in section 1.3. above.

firms H_1 and H_2 do not affect the walk away incentives (i.e. in either case M_X may maximally gain M_1's and M_2's share of B_1 and B_2). Clearly in the latter situation, there is less of a reason to create H_1 and H_2, except possibly when the benefits B_1 and B_2 are so substantial that the strength of charter arrangements is necessary.[33] [34] The above analysis also implies that another situation in which it may not be useful to create holding firms is the case where B_X is evenly distributed over owners. This could occur when B_X mainly consists of the gains from a possible future take-over of firm X (i.e. according to European take-over law, a bidder has to pay all shareholders the same price).[35] Finally, ownership that is solely aimed at creating veto power over holding firm dissolution or changes in super-majorities (i.e. to stop bad games ex-post), is also an obvious candidate for replacement by appropriate arrangements in syndicate contracts.

4.2. Other alternatives

Likewise syndicate agreements, other co-operative forms may not always be as efficient as the holding structure in solving this paper's renegotiation problem. This will prove to be the case for the following well known co-operative forms.

A. Cross-directorship. See the discussion in section 1.2.

B. Direct ownership. As explained in the above section, direct ownership supplemented with syndicate agreements may be vulnerable to contract disintegration, especially when M_X is not capable of maintaining majority control over company X without the help of holding constructions. However when M_X keeps a majority stake in firm X, or if the control benefits of this firm are limited, direct ownership is likely to be the preferred solution.

C. Joint venture. It is not always obvious to define the assets that should go into a joint venture. It may also be strategically unsound to shift particular assets into such an arrangement. For example, the co-operation may involve assets that are of prime importance to M_X. Hence if M_X puts those into a joint venture with 50/50 % ownership (either with M_1 or with M_2), M_X may lose control over important pieces of company X's business. Furthermore the same assets that are used to produce B_1 may also be important in

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[33] If B_1 (B_2) is large and hence blow-up risk is substantial, a syndicate contract could still be sustainable if, according to the standard super-majority rules of the law, M_1 (M_2)'s ownership constitutes a minority that may block charter changes. For this blocking power remains, even if the syndicate agreement disintegrates (see also section 1.2.). Furthermore it is interesting to note that in the earlier indicated examples Unilever and Shell, where one may expect the benefits of the co-operation to be substantial, the co-operation rules are imbedded in the charters.

[34] The trade off between the use of syndicate contracts and holding firms can be regarded as an example of the Coasian trade off between the use of the market (private contracts) and the use of a firm (the holding firm). This comparison to the Coasian trade off was suggested to me by G. Elewaut.

[35] In that case B_X would be paid out as a security benefit instead of as a private benefit. Note that the syndicate agreement mentioned in section 1.2. above could be an example of such a case.

producing B_2, B_3,.... So if one opts for a joint venture, it should involve M_X, M_1, M_2, M_3,..., and be governed by a syndicate contract to sustain the required pivotal equilibrium. Furthermore, as more co-operations are included, the possible gains from walking away from the syndicate agreement may increase. Finally, even if the contract is sustained, any subsequent change requires everybody's consent. Hence a maxi joint venture with a large number of partners constitutes an inflexible solution.

D. Merger. It is well known that many mergers do not pay off, ex-post, because of the costs arising from fully integrating several companies. Clearly, the holding arrangement creates flexible opportunities for partial co-operation between (possibly many) firms, while avoiding the problems of a complete integration.

5. CONCLUSIONS

This paper offers a new rationale for the existence of European multi-holding groups with inter and intra-group ownership. It shows that maintenance of pivotal equilibria and capital constraints are likely to be important factors in determining ownership structures. The paper also explores the interaction between holding firms and syndicate agreements and explains why, in practice, these contracts are often used in conjunction with holding arrangements. Next to explaining several observed regularities in holding group structures, the findings of the paper have several implications. In particular, the paper predicts that when capital constraints are less of an issue, and co-operation between companies (or different parties) is organized through holding firms, relatively simple holding structures are likely to emerge. Similarly, it predicts that the holding structures of groups with few co-operations with outsiders are likely to be relatively simple also. Furthermore if there are inter-group connections, the findings imply that holding groups mainly own stakes in holding firms of other groups that control companies in businesses related to the businesses the former group controls. Finally, the insights of the paper are also consistent with recent empirical evidence on the observed limited impact of block trading by holding groups.

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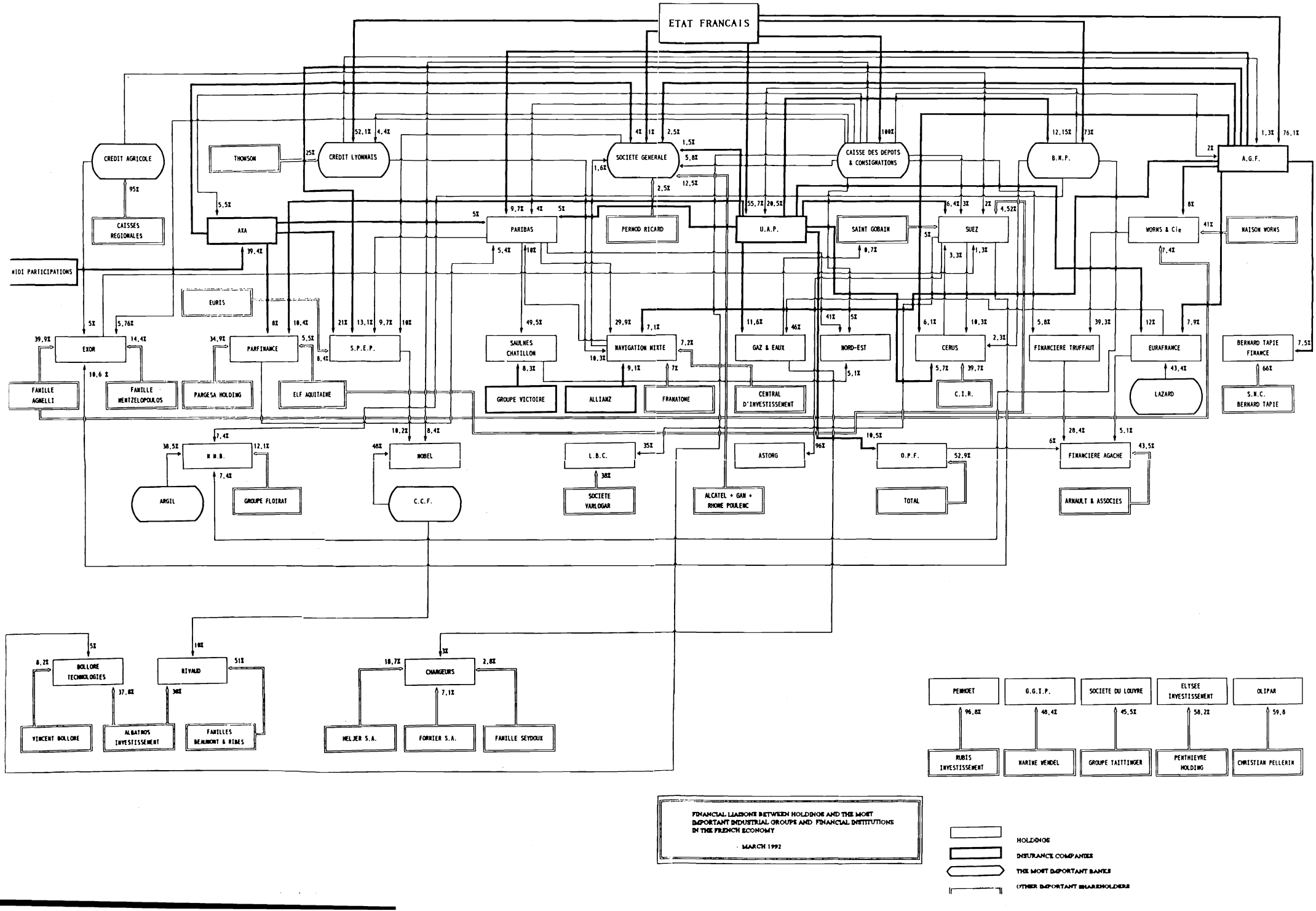
Appendix A: Some examples of holding group structures

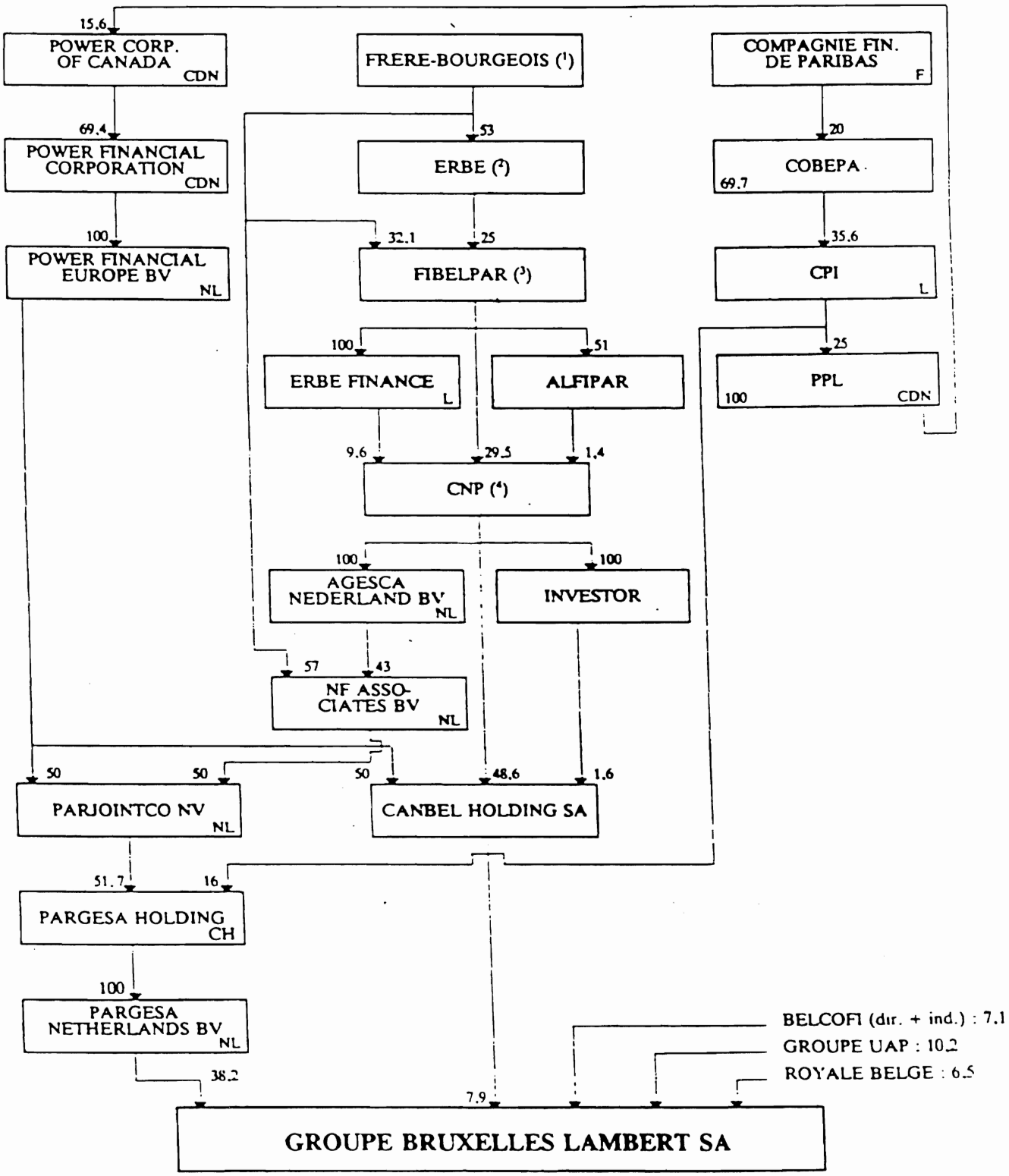
Appendix A contains the following examples:
- Inter connections between the main French holding groups.
- A simplified representation of Groupe Bruxelles Lambert (GBL) a Belgian holding group. This is followed by a close up of Tractebel, one of GBL's participations in which it shares control with French Suez daughter Société Générale (Tractebel is indicated in GBL's ownership chart on page 5 of this appendix). Finally a closer look of Watco, one of the companies under the control of Tractebel is provided also (Watco is indicated in Tractebel's ownership chart on page page 10) .
- A representation of the ownership structure of Swedish Volvo.

1. Inter Connection between the main French holding groups



Appendix 2

2. A Belgian group: Groupe Bruxelles Lambert (GBL)



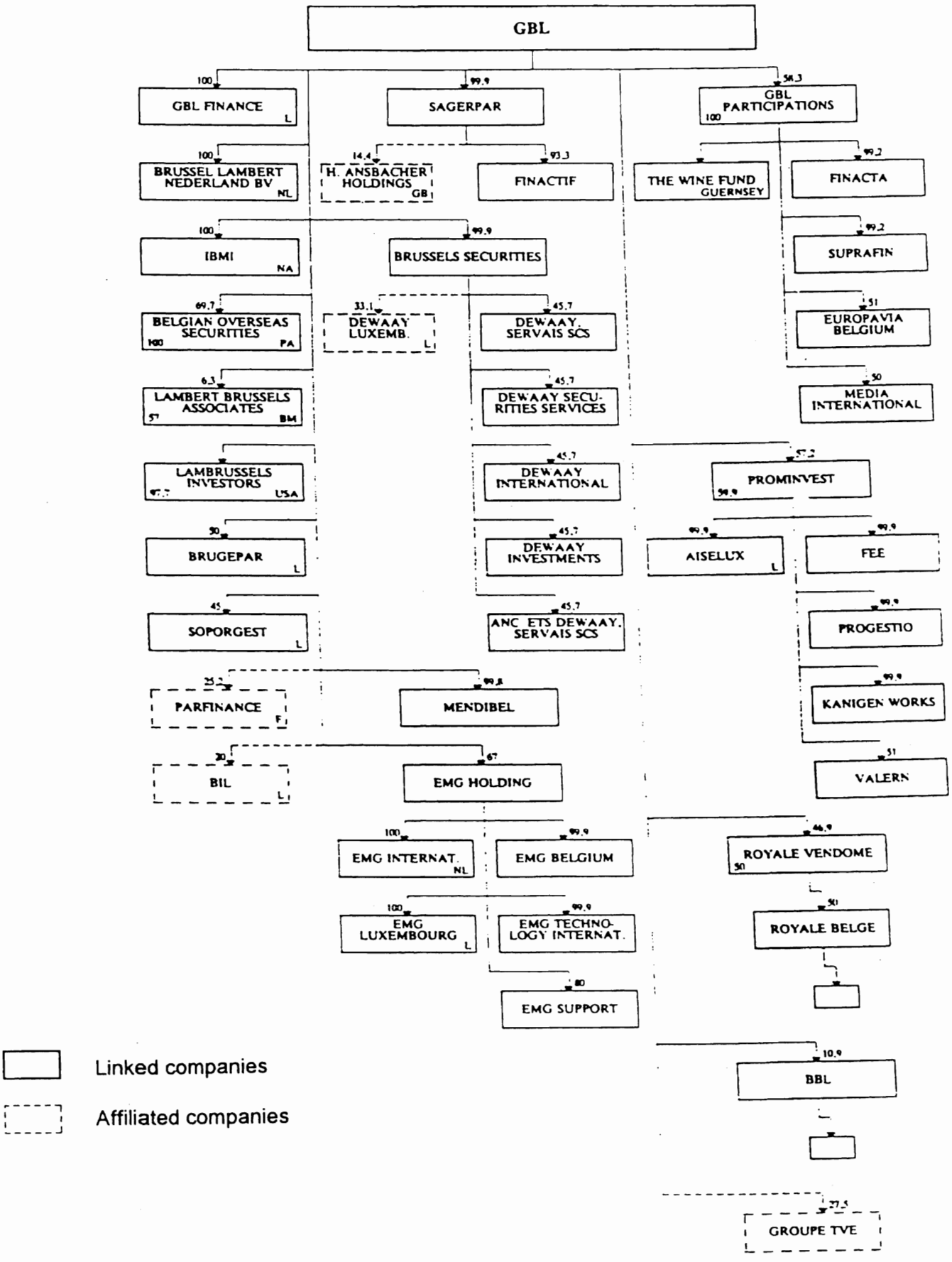
(1) A. Frère is the major shareholder (with the members of his family), by means of an "administratiekantoor" (Belgian law), of Frère-Bourgeois SA and Hermes Finance SA, which have together 94 % of SA Financière de la Sambre.

(2) And his filial of 99,9 % Carges

(3) The other shareholders of Fibelpar are Electrafina (13,1 %), Société Générale de Belgique (10 %), Almabo (7,4 %), Group AG (5%), Royale Belge (5%) and UAP (2,5 %)

(4) The other shareholders of CNP are La Mosane (filiale of Cobepa) (10 %) and Royale Belge (7,2 %)

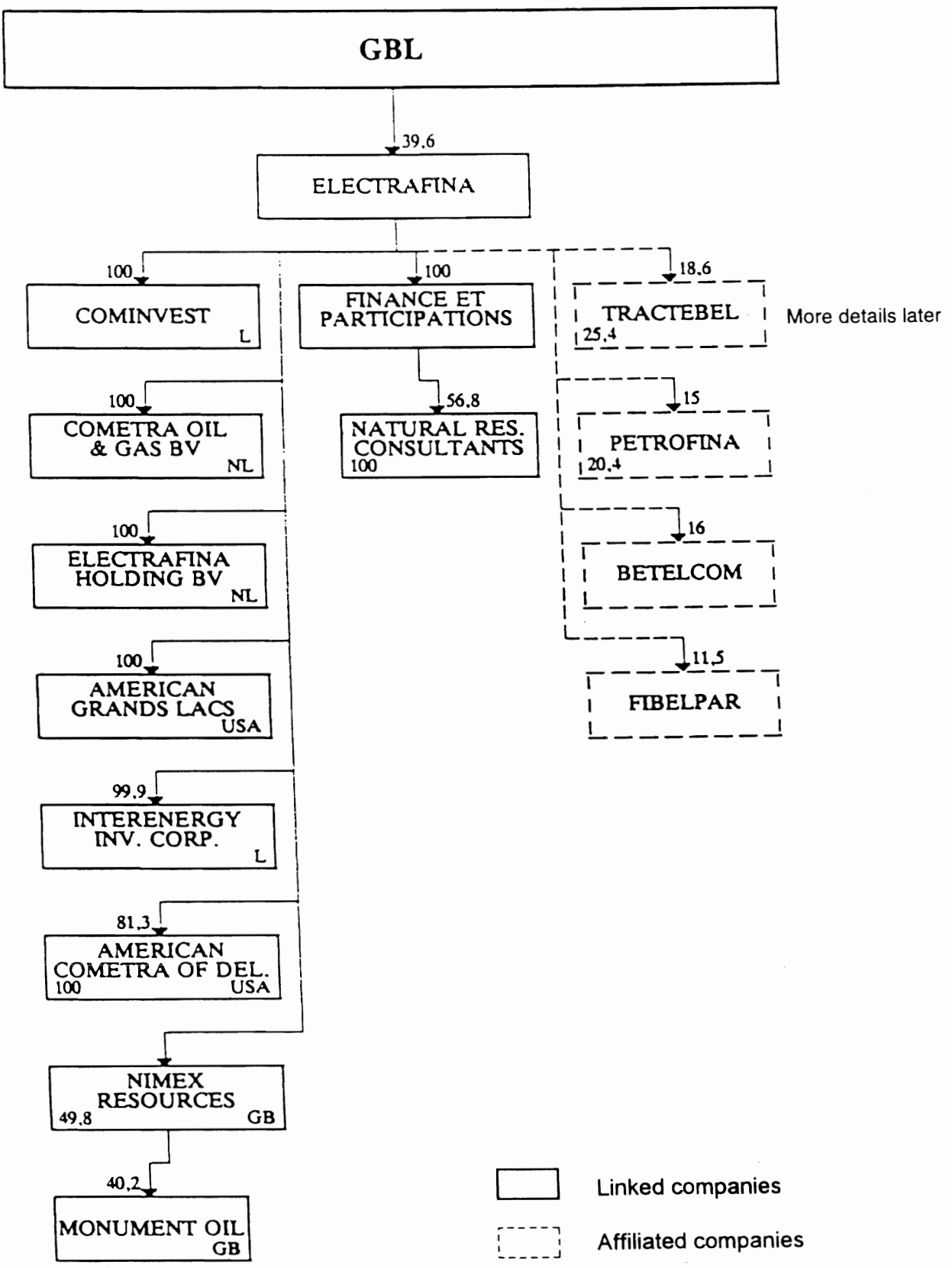
Shareholders of Group Bruxelles Lambert



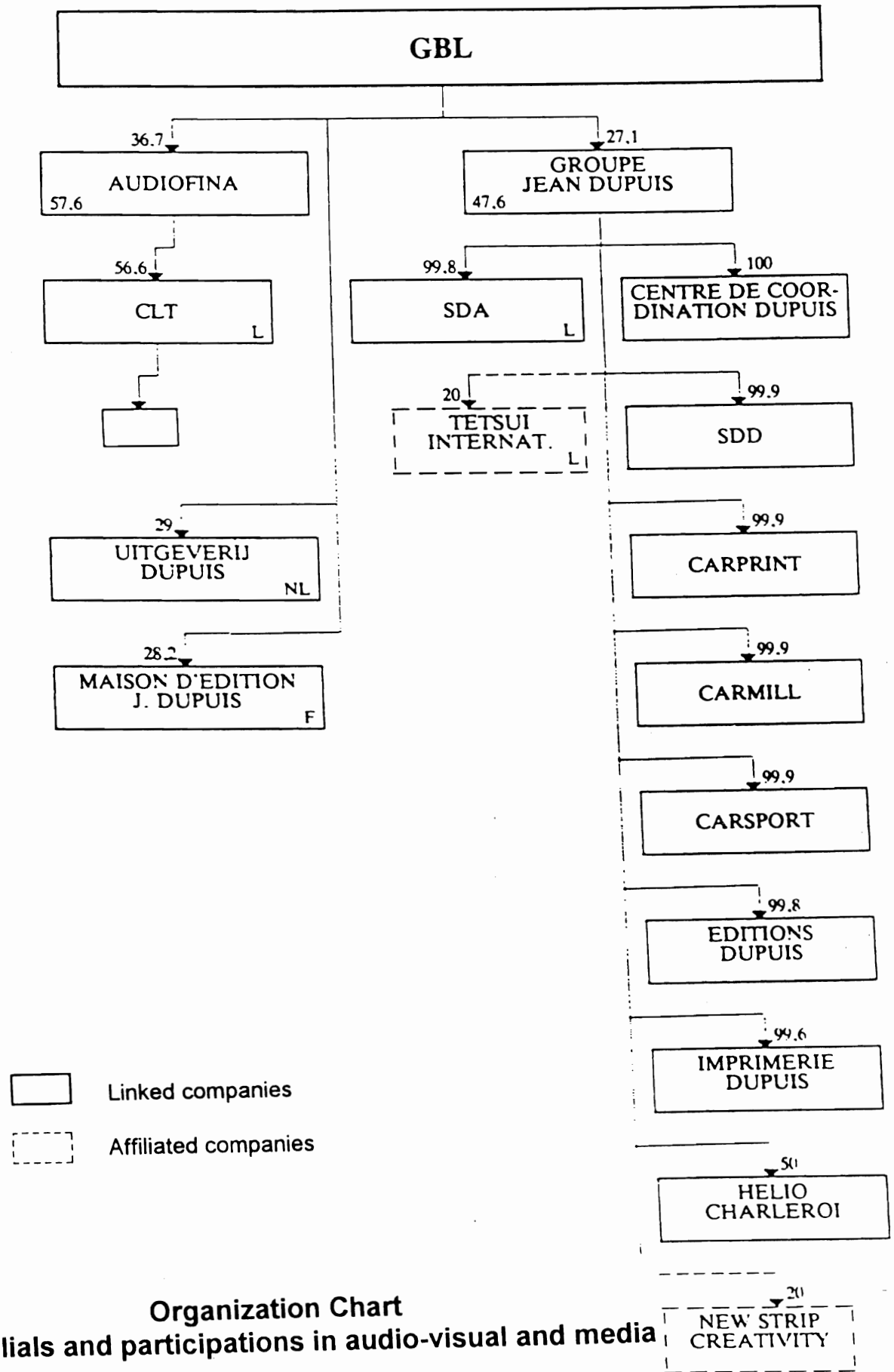
Organization Chart

GBL: Filials and participations in financial institutions, banking and ensurance companies

Group Bruxelles Lambert



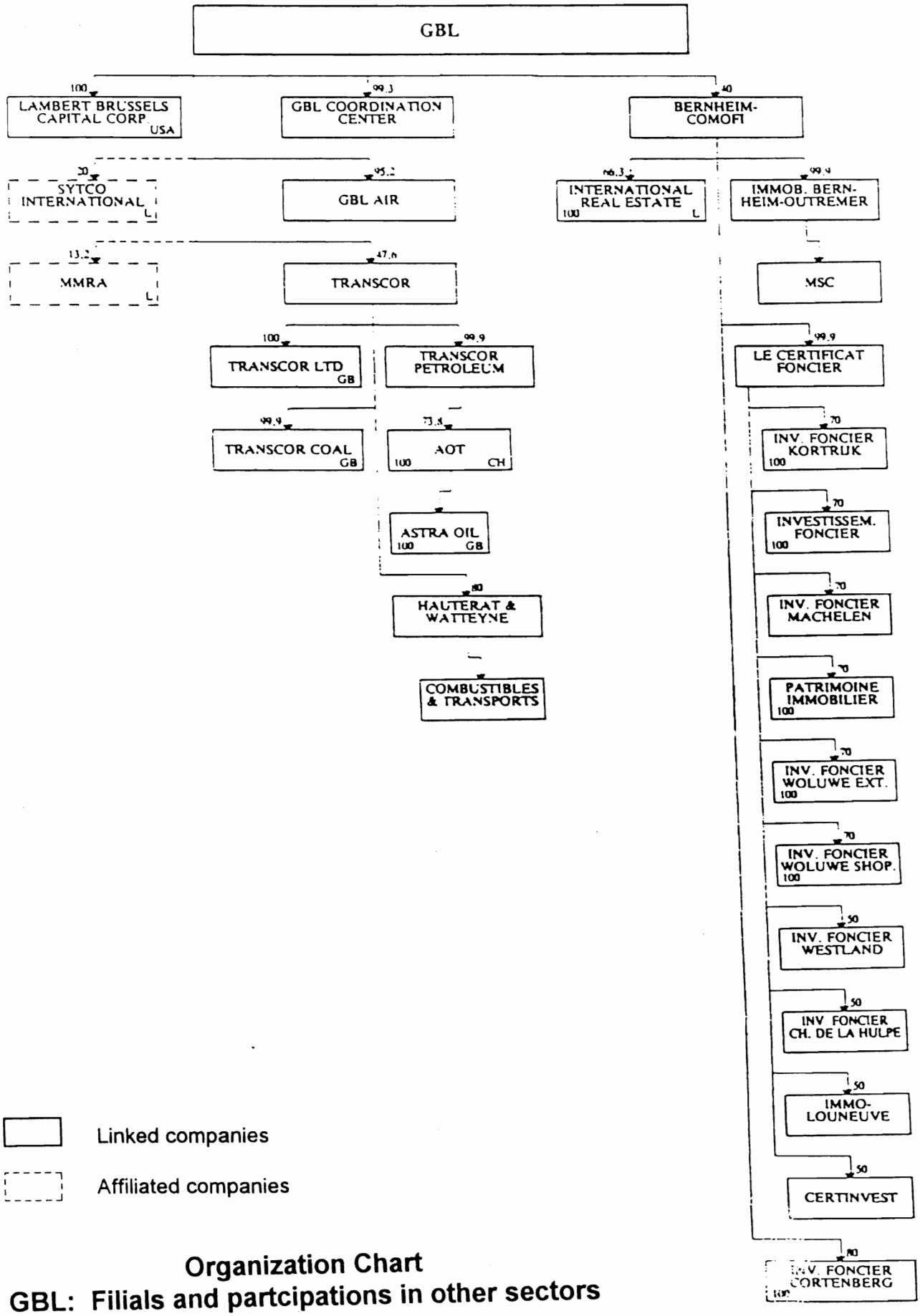
Organization Chart
GBL: Filials and participations in the energy sector and in research centres



Organization Chart

GBL: Filials and participations in audio-visual and media

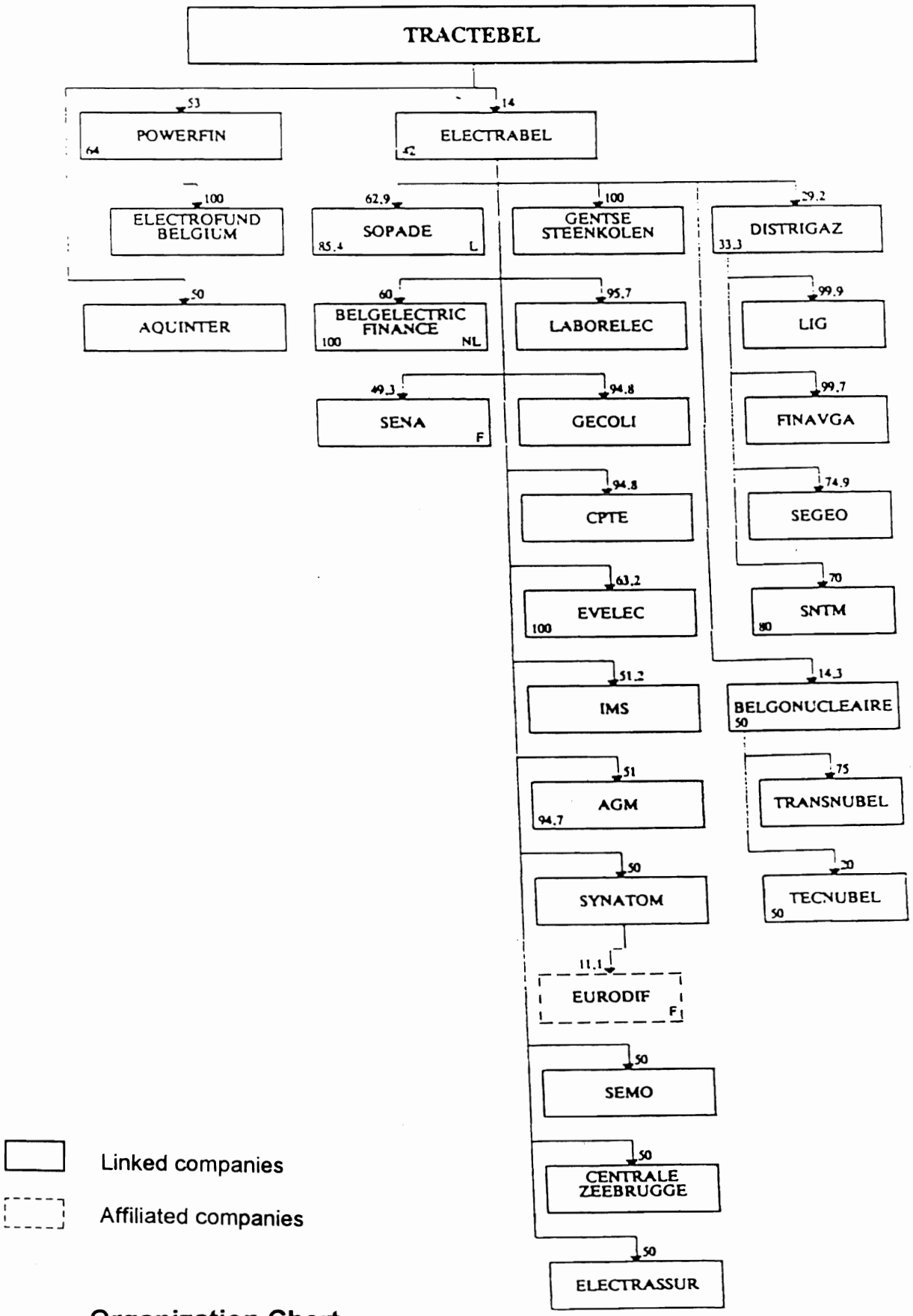
Group Bruxelles Lambert



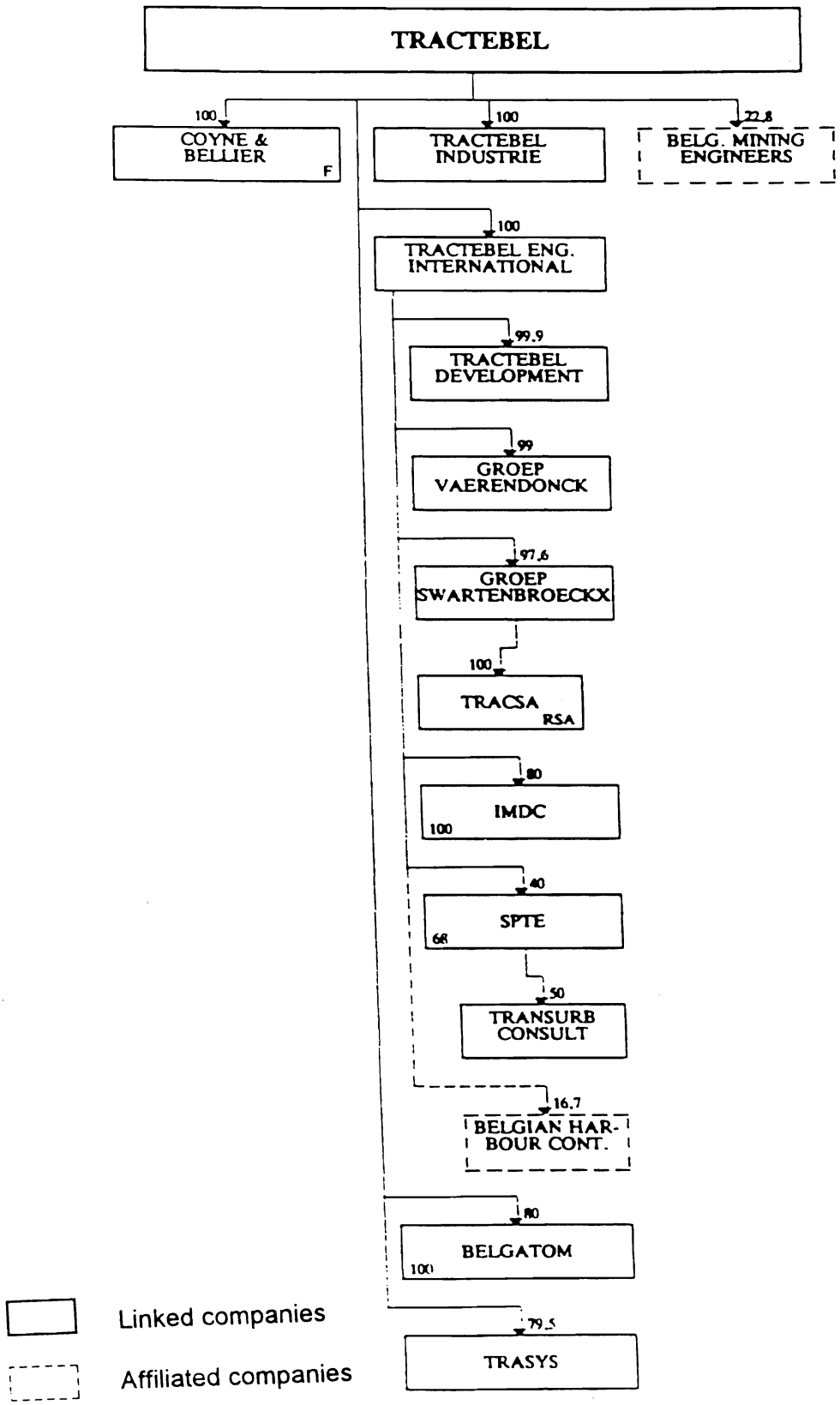
Organization Chart

GBL: Filials and partcipations in other sectors

Zooming in on Tractebel

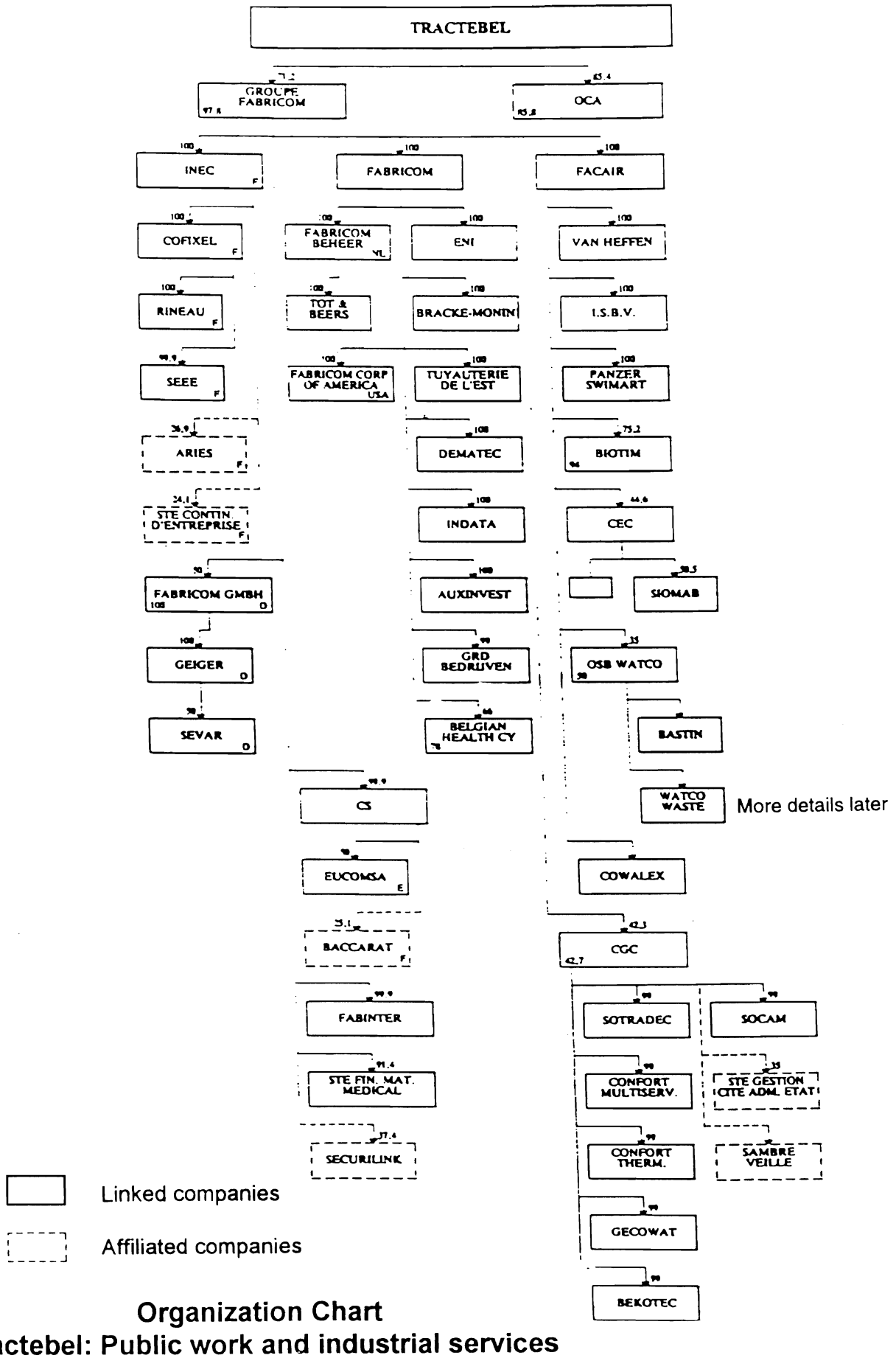


Organization Chart
Tractebel: The energy sector



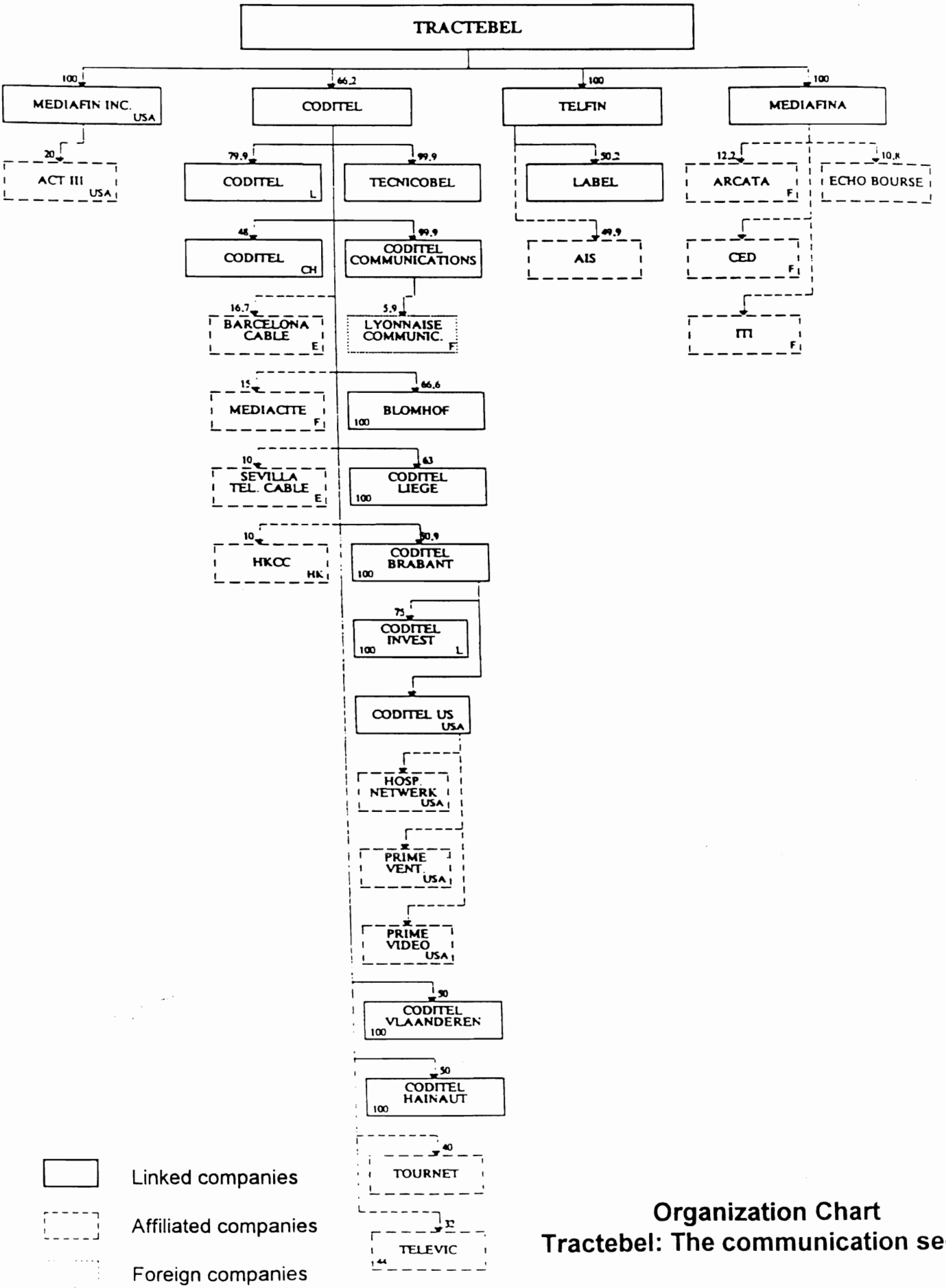
Organization Chart
Tractebel: The engineering sector

Zooming in on Tractebel



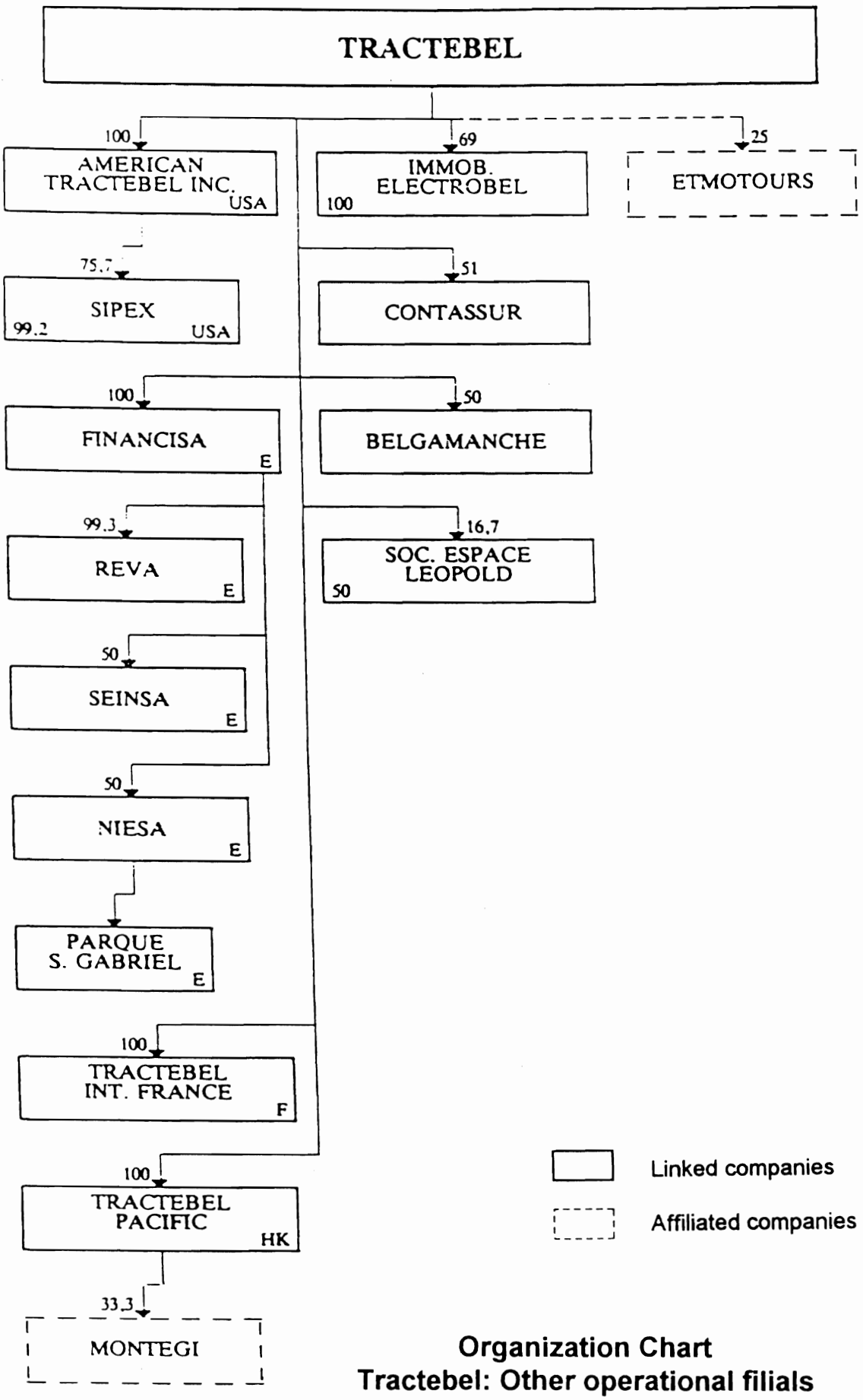
Organization Chart
Tractebel: Public work and industrial services

Zooming in on Tractebel



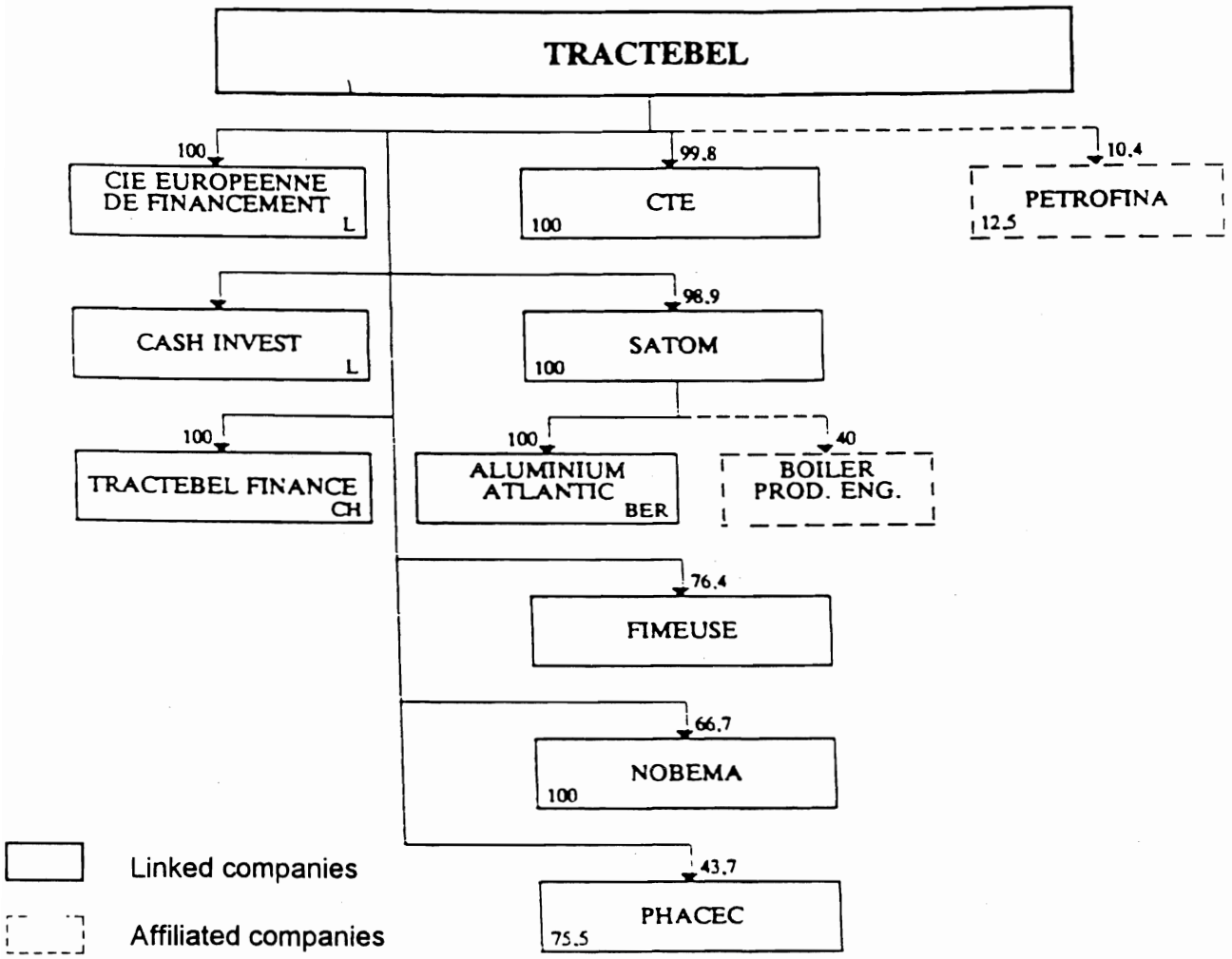
Organization Chart
Tractebel: The communication sector

Zooming in on Tractebel



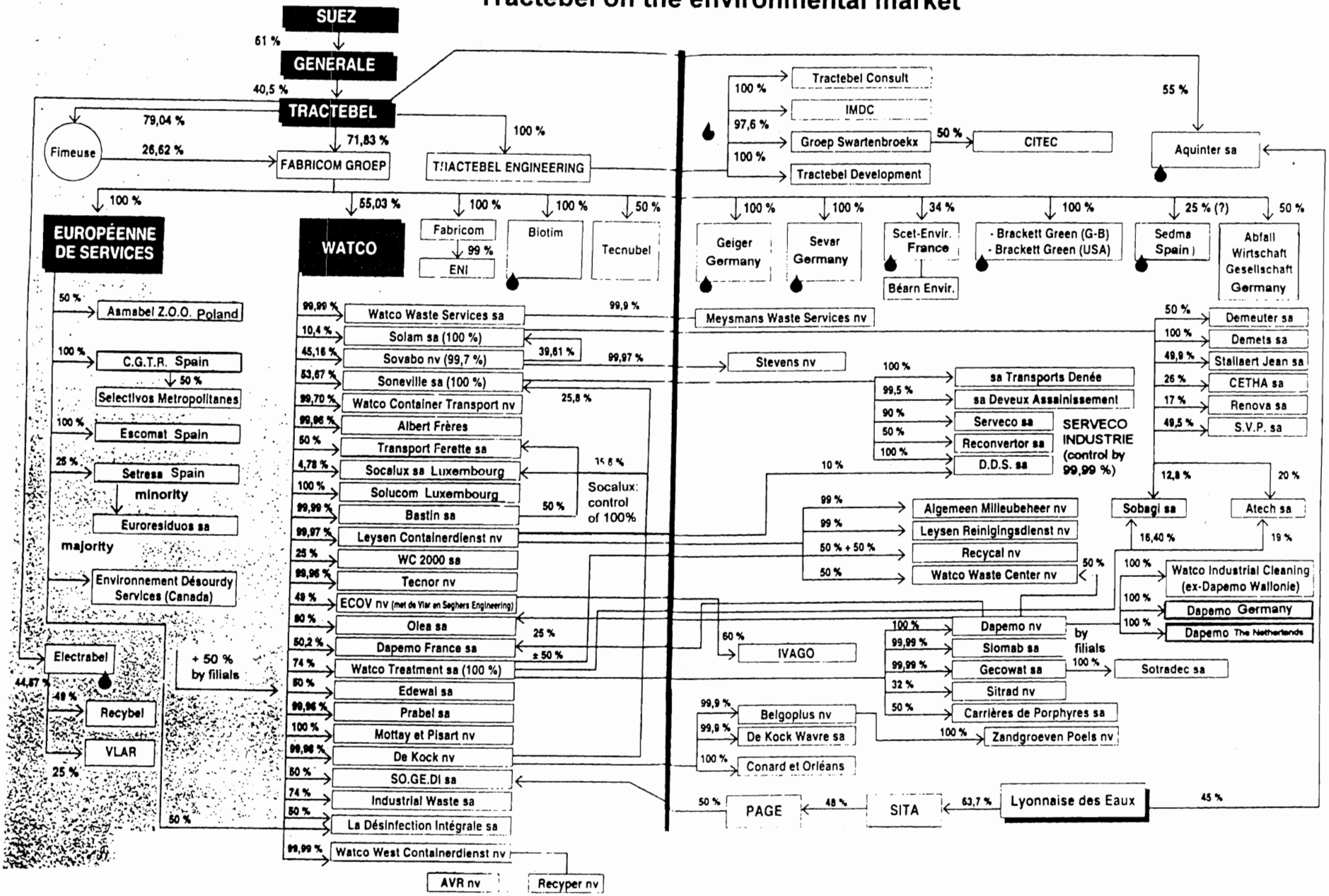
Organization Chart
Tractebel: Other operational filials

Zooming in on Tractebel



Organization Chart
Tractebel: Financial filials and other companies

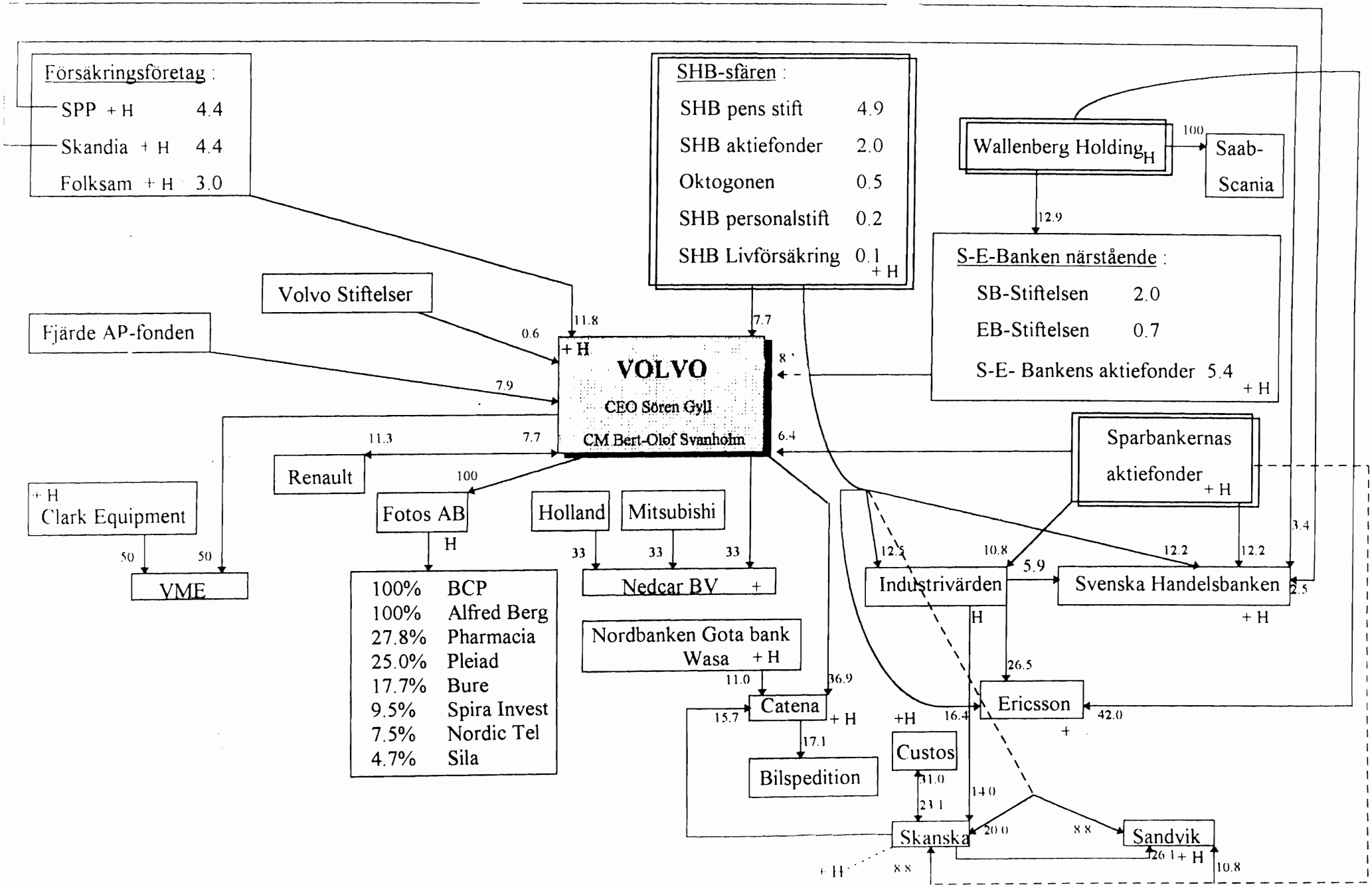
Tractebel on the environmental market



♦: activities in the water sector (purge, distribution, investigation, material). Most of the other companies are active in the waste sector (collection, transformation, storage,

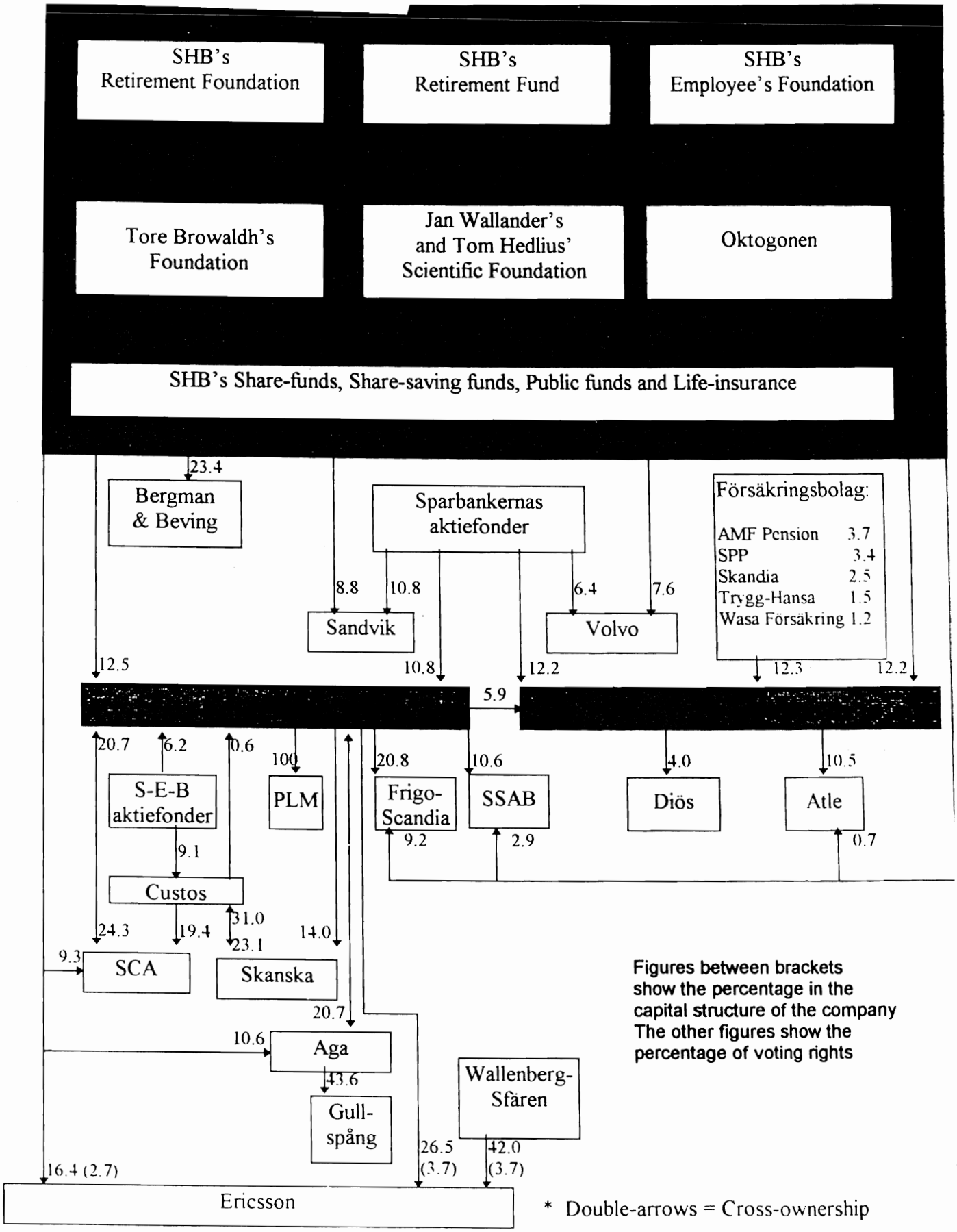
The percentages between brackets in the borders show real control.

Source: Incidences, La Lettre de l'Environnement

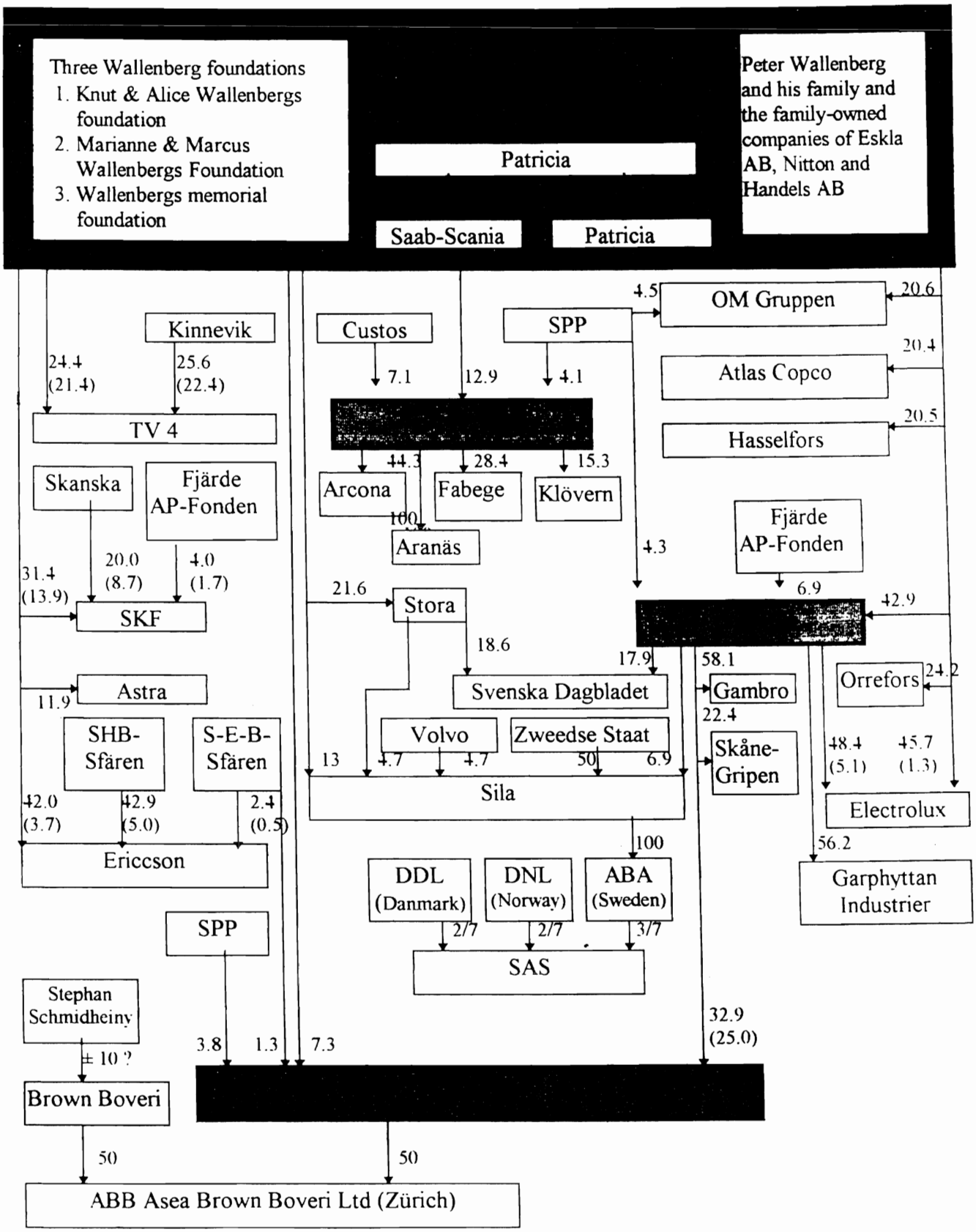


\+ quoted on the stock exchange
H Holdings

Source: Hendrik Van Asbroeck



Source: *Hendrik Van Asbroeck*



Figures between brackets show the percentage in the capital structure of the company
The other figures show the percentage of voting rights

Source: Hendrik Van Asbroeck

Appendix B: N parallel holding firms

1. The conditions for the case with N co-operations and parallel holding firms

Consider N co-operation opportunities i (i = 1,...,ik,...N), each with a distinctive B_i and E_i. These opportunities involve in sum $n \geq N$ parties M_j other than M_X. Each of the M_j (j = 1,...,jl,...n°) may participate in several co-operations. A solution to the renegotiation problem involves the following steps:

A. Creation of committees.

A.1. Associate with each co-operation an observable event E_i.

A.2. Create N parallel holding firms, one for each co-operation. Each holding firm H_i is governed by simple majority (+ 1 share), except when its event E_i is active; then a super-majority of S_{Hi} (+ 1 share) is required. M_X (M_j) owns $s_{MX,Hi}$ ($s_{Mj,Hi}$) in holding firm H_i. Futhermore the sum of the ownership in H_i of all M_j (i.e. $M_j \neq M_X$) involved in co-operation i is $\Sigma_j s_{Mj(i),Hi}$. The ownership distribution of every holding firm H_i satisfies the following conditions:

- M_X has majority control:

$$s_{MX,Hi} > 0.5 \qquad \text{(B1)}$$

- when E_i is active and one M_{jl} (i) in the co-operation does not agree, the required super-majority is not reached:

$$s_{MX,Hi} + \Sigma_j s_{Mj(i),Hi} - s_{Mjl(i),Hi} \leq S_{Hi} \qquad \text{(B2)}$$

- when E_i is active and all parties in the co-operation agree, the required majority is reached:

$$s_{MX,Hi} + \Sigma_j s_{Mj(i),Hi} > S_{Hi} \qquad \text{(B3)}$$

It is clear from preceding conditions, that capital constraints may be a problem for M_X (i.e. (B1)). By choosing the super-majority appropriately such constraints are not a problem for the M_j, at least as long as M_X is not capital constrained. In particular if M_X can take up virtually all of the shares in each H_i and S_{Hi} imposes unanimity, the M_j only need to hold very few shares.

B. Structuring the ownership of company X.

Every parallel holding firm owns $s_{Hi,X}$ of the shares of company X. Similarly M_X (M_j) holds a fraction $s_{MX,X}$ ($s_{Mj,X}$) of firm X's shares. Finally denote by $\Sigma_j s_{Mj,X}$ the total sum of direct ownership of all M_j (i.e. $M_j \neq M_X$) and by S_X (+ 1) the general super-majority rule in company X.[1] Then the ownership distribution ($s_{Hi,X}$,

[1] An event dependent super majority would work also.

$s_{MX,X}$, $s_{Mj,X}$) supplemented with the general super-majority rule S_X in company X, gives M_X control and provides the holding firms H_i with an event specific veto if:

- M_X has control when no event E_i is active:

$$\Sigma_i\ s_{Hi,X} + s_{MX,X} > S_X \qquad \text{(B4)}$$

- when event E_{ik} is active, no required majority can be found unless all M_j involved in co-operation ik agree with M_X:

$$\Sigma_{i\neq ik}\ s_{Hi,X} + s_{MX,X} + \Sigma_j\ s_{Mj,X} - \Sigma_j\ s_{Mj(ik),X} \leq S_X \qquad \text{(B5)}$$

- when all parties involved in co-operation ik agree, the required super-majority S_X is reached:

$$\Sigma_i\ s_{Hi,X} + s_{MX,X} + \Sigma_j\ s_{Mj(ik),X} > S_X \qquad \text{(B6)}$$

The following feasibility conditions have to be met also:

- ownership is non-negative:

$$s_{MX,Hi},\ s_{Mj,Hi},\ s_{Hi,X},\ s_{MX,X},\ s_{Mj,X} \geq 0 \text{ for all i,j} \qquad \text{(B7)}$$

- all shares in holding firms H_i and company X are held by someone:

$$s_{MX,Hi} + \Sigma_j\ s_{Mj(i),Hi} = 1 \text{ for all } H_i;$$

$$\Sigma_i\ s_{Hi,X} + s_{MX,X} + \Sigma_j\ s_{Mj,X} = 1 \text{ for company X} \qquad \text{(B8)}$$

To define capital constraints, a specification of security values is needed. For simplicity the total security value of company X and holding firm H_i is rescaled to 1 and h_i ($h_i \leq 1$) respectively. Hence if M_X or the other participants are capital constrained, the following conditions have to be added:

$\Sigma_i\ h_i{*}s_{MX,Hi} + s_{MX,X} < K_{MX}$ with K_{MX} $(0 < K_{MX} \leq 1)$

similarly for any M_j:

$$\Sigma_i\ h_i{*}s_{Mj,Hi} + s_{Mj,X} < K_{Mj} \quad \text{with } 0 < K_{Mj} \leq 1 \qquad \text{(B9)}$$

and K. a capital constraint.

Obviously (B4) is a more stringent condition than (B6). Hence abstracting from the feasibility constraints (B7), (B8) and (B9), (B4) and (B5) imply that the problem is solved whenever for any co-operation ik, ownership positions can be found such that:

$\Sigma_{i\neq ik}\ s_{Hi,X} + s_{MX,X} + \Sigma_j\ s_{Mj,X} - \Sigma_j\ s_{Mj(ik),X} < \Sigma_i\ s_{Hi,X} + s_{MX,X}$

or after simplification:

$$\Sigma_j\ s_{Mj,X} - \Sigma_j\ s_{Mj(ik),X} < s_{Hik,X} \qquad \text{(B10)}$$

Condition (B10) implies that, excluding M_X, the direct ownership position in company X of all parties not involved in co-operation ik should be below the ownership of the holding firm H_{ik}. Hence when there exists a solution for inequality (B10) consistent with some S_X satisfying $0.5 \leq S_X \leq 1$, the case with N parallel holding firms is solved. Such a solution can certainly be found whenever M_X sells only a limited fraction of the X shares to the M_j. For example, suppose M_X maintains sufficient ownership so that, if the holding firms are filled with all ownership of the

M_j, M_X keeps its majority in every H_i. Then $s_{Mj,X} = 0$ and (B10) is satisfied. Furthermore if a high enough S_X is chosen (e.g. $S_X = 1$), conditions (B4) and (B5) are met.

2. Proof of proposition 1.

In the symmetrical case with N co-operations and n ($n < n^{\circ}$) non overlapping M_j (in addition to M_X) per co-operation, M_X has to solve the following linear problem:

Minimize $N*(s_{H,X}/2 + 1 \text{ share}) + s_{MX,X}$

$s_{MX,H}$; S_X; $s_{MX,X}$

subject to:

$N*s_{H,X} + s_{MX,X} > S_X$

$(N-1)*s_{H,X} + s_{MX,X} + (N-1)*n*s_{M,X} \leq S_X$

$s_{H,X}, s_{MX,X}, s_{M,X} \geq 0$

$N*s_{H,X} + s_{MX,X} + N*n*s_{M,X} = 1$ [2]

where, because of the symmetry, all $s_{MX,Hi} = s_{MX,H}$ and also all $s_{Mj,X} = s_{M,X}$.
Note that in the above objective function, $s_{H,X}/2$ represents a fraction of ownership. In contrast (+ 1 share) is not a fraction. It represents the small quantity of additional votes that avoids the tie that would occur if one party or colluding group of parties, would obtain a fraction of the votes exactly equal to the required majority, whereas another party or group of parties would own a fraction exactly equal to (1 - required majority).

The solution of the above program can be derived directly. The first two constraints imply:

$(N-1)*n*s_{M,X} < s_{H,X}$ (i.e. the symmetrical case version of constraint (B10)).

M_X can continue to add co-operations N until this condition becomes binding or:

$(N-1)*n*s_{M,X} + 1 \text{ share} = s_{H,X}$ (B11)

Substituting this minimal value of $s_{H,X}$ in the condition that all ownership of company X must add up to 1, yields:

$N*s_{H,X} + s_{MX,X} + N*n*s_{M,X} =$

$= N*(N-1)*n*s_{M,X} + N \text{ shares} + s_{MX,X} + N*n*s_{M,X} = 1$ (B12)

Note that for every share M_X adds to a holding firm, some other participant M can add one more share too without endangering M_X's majority in the holding firm. As the majority owner implicitly uses these minority shares in exercising control over X,

[2] As constraint (B6) is less stringent than constraint (B4), the symmetrical version of the former has been dropped. Also the capital constraint has been dropped as it is assumed to be non binding.

it is interesting for a capital constrained M_X to put all its ownership into the holding firms, and choose $s_{MX,X} = 0$. Taking this into account, and solving equation (B12) for $s_{M,X}$ yields:

$s_{M,X} = [1 - N \text{ shares}]/(N^2*n)$

Substituting this value back into (B11) yields:

$s_{H,X} = (N-1)/N^2 + 1/N$ shares

When these values for $S_{M,X}$ and $S_{H,X}$ are substituted into the first two constraints of the minimization program, these constraints imply:

$S_X = (N - 1)/N$

If one takes into account only integer amounts of shares, the solution becomes:

$s_{M,X} = 1/(N^2*n) - 1$ share (B13)

$s_{H,X} = (N-1)/N^2 + 1$ share (B14)

$S_X = (N - 1)/N + (N-1)$ shares

Finally, the proposition's ownership proportions in the holding firms H are obvious from preceding arguments. The bounds for S_H can readily be seen by considering the symmetrical case version of conditions (B2) and (B3).

Appendix C

1. The ownership conditions for an N-holding cascade system

The generalization towards a cascade system with N holding firms is straightforward. One only needs to assign to each holding firm a number i according to its place in the cascade and replace conditions (B1) to (B9) by the following ones:

- M_X has majority control in H_1 and each holding firm H_{i-1} has majority control in holding firm H_i:

$s_{MX,H1} > 0.5$

$s_{Hi-1,Hi} > 0.5$ for all i=2,...N (C1)

- when event E_i is active and one party $M_{jl}(i)$ does not agree, super-majority is not reached:

$s_{MX,H1} + \sum_j s_{Mj(1),H1} - s_{Mjl(1),H1} \leq S_{H1}$

$s_{Hi-1,Hi} + \sum_j s_{Mj(i),Hi} - s_{Mjl(i),Hi} \leq S_{Hi}$ for i=2,...N (C2)

- when event E_i is active and all parties in co-operation i agree, super-majority is reached:

$s_{MX,H1} + \sum_j s_{Mj(1),H1} > S_{H1}$

$s_{Hi-1,Hi} + \sum_j s_{Mj(i),Hi} > S_{Hi}$ for all i=2,...N (C3)

- M_X has control in X whenever no event E_i is active:

$s_{HN,X} + s_{MX,X} > S_X$ (C4)

- when event E_{ik} is active, S_X can be reached only if the $M_j(ik)$ agree:

$s_{HN,X} + s_{MX,X} + \Sigma_j s_{Mj,X} - \Sigma_j s_{Mj(ik),X} + \text{public} \leq S_X$ (C5)

for every ik = 1...N;

$s_{HN,X} + s_{MX,X} + \Sigma_j s_{Mj(ik),X} > S_X$ (C6)

- the technical feasibility conditions are obvious, and the capital constraint conditions become:

$h_1 * s_{MX,H1} + s_{MX,X} < K_{MX}$ and

$\Sigma_i h_i * s_{Mj,Hi} + s_{Mj,X} < K_{Mj}$ (C9)

2. Proof of proposition 2

Let us first consider the maximization of the fraction of non pivotal shares in any one of the N holding firms H_i. This maximal portion of non pivotal shares can be obtained as a solution to the following program:

Max $(1 - s_{MX,H} - n.s_{M,H})$

$S_H, s_{M,H}, s_{MX,H}$

subject to:

$s_{MX,H} + n * s_{M,H} > S_H$ (C1O)

$s_{MX,H} + (1 - s_{MX,H} - n * s_{M,H}) + (n-1) * s_{M,H} \leq S_H$ (C11)

$S_H \geq 0.5$; $s_{M,H} \geq 0$; $s_{MX,H} > 0.5$

where because of the symmetry, $s_{MX,Hi} = s_{MX,H}$ for all H_i and $s_{Mj,Hi} = s_{M,H}$ for all M_j and H_i.

The program can be solved directly by noting that the maximal amount of non pivotal shares is equal to [$s_{M,H}$ - 1 share] or $1 - s_{MX,H} - n * s_{M,H} = s_{M,H}$ - 1 share. Hence $s_{M,H} = (1 - s_{MX,H} + 1 \text{ share})/(n + 1)$. Clearly this amount is maximized if $s_{MX,H}$ is minimized, i.e. when $s_{MX,H} = 0.5 + 1$ share. Substituting this value into the preceding expression for $s_{M,H}$ yields: $s_{M,H} = 0.5/(n + 1)$. Furthermore (C11) simplifies to: $1 - S_H \leq s_{M,H}$ which implies that $s_{M,H}$ is maximized when the L.H.S. of the condition is maximized or when S_H is chosen so that $1 - S_H = s_{M,H}$. Hence $S_H = 1 - 0.5/(n + 1)$.

Finally, when the values for $s_{M,H}$ and $s_{M,X}$ from proposition 1 are substituted into the first two constraints of the programming problem of appendix B, one obtains:

$(N-1)/N + N$ shares $> S_X$ and

$(N-1)^2/N^2 + (N-1)$ shares $+ (N-1) * n/(N^2 * n) \leq S_X$